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DAM CONSTRUCTION IN THE TENNESSEE VALLEY.

(*Continued from page* 43.)

As stated in the first article of this series, we are following our description of the Norris Dam with some account of the engineering features of the Wheeler Dam, which was the second major constructional project undertaken by the Tennessee Valley Authority. It is situated 15½ miles upstream from the Wilson Dam, the position being as indicated in the map of the Tennessee Valley Authority's area, given in Fig. 1 on page 1, *ante*. Although the dam incorporates a power plant, consisting of two 45,000-h.p. turbine sets, its main purpose is not the formation of a storage reservoir in the same way as the Norris Dam. Its essential functions are the improvement of flood control, and the regulation of navigation. None the less, the controlled length of river behind the dam has an area of 640,000 acres at the normal elevation of 555 ft. above sea level and has a total capacity of 1,035,000 acre-ft. The lake which is formed provides slack water upstream to the Guntersville Dam, a distance of 86½ miles. The storage capacity for flood control is 350,000 acre-ft. between levels 550 ft. and 556 ft.; during periods of extreme flood danger, a further storage capacity of 140,000 acre-ft. is available between levels 556 ft. and 558 ft.

A general view of the completed dam, which is a mass-concrete structure 6,310 ft. long, is given in Fig. 29, on this page, an elevation and plan being given in Figs. 30 and 31, on Plate VII. Starting from the south end of the dam, that is, the end in the foreground of Fig. 29, it consists of a non-overflow section, 177·5 ft. long; 613 ft. occupied by the power plant; another non-overflow section, 717·5 ft. long, this including a 45-ft. trashway near the power plant; a 2,700-ft. spillway; a non-overflow section, 1,756 ft. long, which also includes a 45-ft. trashway near the lock; a 162-ft. navigation-lock structure; and, finally, a 184-ft. non-overflow section. The roadway along the top of the dam extends a further 192 ft. to high ground on the north bank. Cross sections though the various parts of the dam are given in Figs. 32 to 36, on Plate VII. The main non-overflow section, shown in Figs. 35 and 36, is 55 ft. wide at the base and 70 ft. high. It is located on a ledge of rock at an average depth of 10 ft. below the river bed. The sections of the concrete dam shown in Figs 35 and 36 are similar, the difference between these figures being that the sections are taken through different parts of the overhead roadway. The taller superstructure of Fig. 36 is occasioned by the ramp at the north end, where the road is carried up on a gradient in order to give greater headroom over the lock. This arrangement has eliminated the necessity for a swing bridge and also has the advantage that the road rises on a moderate slope to the high ground on the north bank. A section of the trashway structure, which applies both to the trashway near the power plant and that alongside the lock, is given in Fig. 34. As will be noted, the crest is 7 ft. below the crest of the non-overflow section, so that there is a small discharge through the trash-racks. When the spillway is not discharging, this causes floating logs and other debris to set towards the trashways, where they may be salved.

Over the spillway section, the dam is provided with an apron, as shown in Fig. 33. The dam proper over the length of the spillway is 54 ft. high and the deepest part of the foundations is 24 ft. below the bed of the river. The total width, including the apron, is 124 ft. The spillway is divided into 60 bays, each provided with a Tainter gate, 40 ft. long and 15 ft. high. Each has a discharge capacity of 8,000 cusecs at normal pool level. Concrete energy-dissipators are built on the top of the toe of the apron in order to retard the velocity of the water as it is discharged on to the river bed, thus preventing erosion. The apron is flanked by end training walls, 5 ft. thick and rising 12 ft. above mean low-water level below the dam. Between these, there are 11 intermediate training walls, parallel to the end walls, but rising only to low-water level. These training walls are shown in Fig. 31, and the tops of the end walls, projecting above the water, can be seen in Fig. 29.

Although the Wheeler Dam was constructed by the Tennessee Valley Authority, preliminary work in connection with it had been done by the United States Corps of Engineers before the Authority came into existence. The Army engineers were concerned with the matter mainly from the point of view of navigation, and the designs they prepared were later recast and worked out in detail by the engineering staff of the United States Bureau of Reclamation. As mentioned in the first article of this series, the Tennessee Valley Act was passed in 1933, but work on the lock, which now forms part of the dam, had been started by the United States Corps of Engineers in December, 1932. As at first planned, the lock was to have a lift of 37 ft., but when the plans were revised this was increased to 50 ft., making it now one of the highest single-lift locks in the United States. The lock is 60 ft. wide and 360 ft. long, the clearance under the overbridge, at high-water level, being 57 ft. The roadway is 20 ft. wide, with a narrow footpath on the downstream side. It is situated 70 ft. above the bed of the river for the greater part of its length, rising to a higher level at its north end, as shown in Fig. 30 and previously mentioned. As shown in the various cross sections, the roadway is, in the main, carried on longitudinal joists supported by concrete piers rising from the top of the dam. For the lock crossing, however, girder trusses are used. Towards the north end, where the roadway is at a higher level, steel lattice towers are introduced in addition to the concrete piers, in order to give greater longitudinal stability. These are shown in Fig. 30. A view of the completed lock, with one of the Tennessee Valley Authority tugs with a barge in tow entering at the upstream end, is given in Fig. 38, on page 82.

As will be seen from the cross-section of the dam through the power plant, which is given in Fig. 32, and from the general view of the completed plant, which forms Fig. 37, on page 82, there is no power-

FIG. 29. COMPLETED DAM, LOOKING FROM SOUTH BANK.

WHEELER DAM AND POWER PLANT, TENNESSEE RIVER.

FIG. 37. POWER PLANT.

station structure of the usual type. The generators project through the top of the main foundation block formed round the water turbines and are protected by removable covers, which are clearly seen in the illustration. The service crane is of the gantry type and is in the open, as shown in Fig. 32. It travels on rails on the top of the main concrete structure, which contains the turbines. The crane is not within the range of the general view given in Fig. 37, but the lower part of one of its supporting legs can be seen in Fig. 39, on page 90, which shows one of the turbine wheels being lowered into position. As shown in Fig. 32, a trash rack and a cut-off gate are provided for each turbine.

The initial installation consists of two 45,000-h.p. vertical fixed-blade propeller-type turbines, direct-connected to 36,000-kVA three-phase 60-period 13,800-volt alternators. These supply a bank of three 24,000-kVA single-phase, 13,800 to 89,000, or 154,000-volt oil-insulated self-cooling transformers, situated in the open on the river-side of the plant, as shown in Fig. 37. Two further views of one of the turbine wheels are given in Figs. 40 and 41, on page 90. The former shows the hub of one of the wheels, and the latter, one of the blades.

The governors, governor and lubricating-oil pumps, and other auxiliary equipment are situated in an operating compartment formed in the upper part of the foundation block, and shown in Fig. 32. Provision is made for admitting compressed air to the turbines, so that the generators can be operated as synchronous condensers for the regulation of voltage on the transmission lines, quick-response excitation being arranged to stabilise the transmission-line load. The main exciters and pilot exciters are direct-connected and are situated in the smaller-diameter casings on the top of the main machine casings. Automatic voltage regulators are fitted for use in connection with the quick-response excitation. Each generator is also provided with automatic carbon-dioxide fire-extinguishing equipment. The turbine governors are of the actuated type with motor-driven speed-response elements, each having its own oil-pressure system, which includes a motor-driven pump, pressure tank and sump tank. The pressure systems of the two governors are interconnected, so that each may act as a stand-by for the other.

FIG. 38. COMPLETED LOCK, LOOKING UPSTREAM.

The trash-rack structures at the penstock entrances, on the upstream face of the dam, are fitted with mechanical rakes for cleaning. The racks and penstock gates are handled by an 85-ton gantry crane, which spans the roadway and travels on tracks which extend for the length of the forebay structure. It can be seen in Figs. 32 and 37. The power-plant service crane, which is of the same type, has a capacity of 270 tons, so that the heavy parts of the turbine sets can be lifted. This crane is arranged so that its hook track extends over the transformer bank. The control building, which is a five-storey structure, 48 ft. wide and 130 ft. long, is situated at the south end of the dam. Alongside

it are the machine shop, battery room, oil storage and purifying shops, etc. A large area is available on which overhaul work may be done on turbine and generator parts. This is served by a 20-ton gantry crane, but the 27-ton crane also covers it, so that heavy machinery parts may be dealt with. The 20-ton crane is shown in Fig. 32. The power-plant section of the dam is constructed so that it will ultimately accommodate ten generating sets, eight draft-tube sections, in addition to the two in use, having been excavated below the river bed. In places, this excavation extends to a depth of 55 ft. The necessary pumps and piping have also been installed, so that the draft tubes may be dewatered, either individually or collectively, when additional generating units are to be installed. The spare positions are also fitted with trash racks and emergency and service gates, the cross-section through these spare positions being similar to that of Fig. 32, with the turbine sets and other machinery omitted.

(To be continued.)

THE ENGINEERING OUTLOOK.

II.—MOTOR VEHICLES, CYCLES AND MOTOR CYCLES.

No figures are available for the production of private cars or commercial vehicles during the past year. Figures are available, however, for new vehicle registrations in this country in recent months, though there is a gap in these figures for the first few months of the war. The increased horse-power tax and the rationing of petrol were in themselves sufficient to cause a sharp decline in new registrations immediately after the outbreak of war, and a further decline took place after July as the result of the partial ban on sales of new cars. Thus new registrations of private cars in Great Britain in the first seven months of 1940 totalled only 30,200, compared with 194,500 in the corresponding period of 1939. Since July, 1940, new registrations have been running at the rate of only 200 to 300 a month. New registrations of commercial vehicles up to July were about one-quarter of the corresponding figures for 1939; after July, however, there was a fall from an average of about 1,400 a month to about 300 a month as the result of the ban on sales except by special permit.

Exports of private cars from the United Kingdom up to the end of 1939 are shown in Table I, herewith.

TABLE I.—*United Kingdom: Exports of Private Cars.*

Year.	Complete Cars.	Chassis.	Total.
1929	23,891	9,901	33,792
1930	19,226	3,983	23,209
1931	17,104	1,888	18,992
1932	26,942	4,855	31,797
1933	33,802	7,226	41,028
1934	34,877	9,030	43,907
1935	44,193	10,327	54,520
1936	51,173	13,592	64,765
1937	53,655	24,458	78,113
1938	44,130	24,127	68,257
1939	43,230	22,767	65,997
1939—Jan.-Aug. ..	35,190	18,793	53,983
Sept.-Dec. .	8,040	3,974	12,014

The figures for the first eight months and the last four months of 1939 show that the rate of export of complete cars and chassis was approximately halved as a result of the outbreak of war, monthly average exports for the period September to December, 1939, amounting to about 3,000, compared with an average of 6,700 in the first eight months of the year. Although figures for individual months are not available, it is probable that, in common with exports from this country generally, exports of private cars fell very sharply in September and October, 1940, while trading conditions were being adjusted to meet war-time requirements, and then recovered for a few months to something like the pre-war level. In April, it was announced that exports of private cars and commercial vehicles together, during the first six months of the war, had averaged 1,000 a week. This compares with a combined average for 1939 of about 1,500 a week. During the first six months of the war, the largest individual markets were Australia, which took 12,350 vehicles; India, 2,600; South Africa 2,160; Malaya, 1,810; New Zealand, 1,160; and Eire, 1,140.

The very high proportion of the total exports accounted for by Australia is undoubtedly a sign of a weakness in Dominion production and considerable importance attaches to the proposal to establish the manufacture of motor vehicles in that country. During 1940, there was a good deal of controversy regarding this project. A feature of the original agreement between the Australian Government and Australian Consolidated Industries, Limited, was an undertaking by the Government to secure to the company a virtual monopoly of the industry for five years. As a result of political pressure, the Government agreed to allow the opposition to inspect the files recording the negotiations. The examination caused the leader of the opposition to declare that Parliament ought not to ratify the agreement with the company when it was submitted in April. Nevertheless, the development of the Australian industry and some permanent decline in purchases from this country appears to be inevitable.

A more serious development, so far as current British exports are concerned, was the ban imposed on September 1 on imports of car chassis (excluding chassis for commercial vehicles) from any country into Australia, for a period of nine months. The initiative for the imposition of this ban came from Australian motor dealers since, owing to the imminence of petrol rationing, allowing sufficient petrol for only 40 miles a week to private owners, the industry was reported to have about 8*l.* million worth of new cars unsold. The Australian Government approved the ban on the ground that it would materially ease the exchange situation.

TABLE II.—*United Kingdom: Exports of Commercial Vehicles.*

Year.	Complete Vehicles.	Chassis.	Total.
1929	2,636	5,583	8,219
1930	2,486	3,059	6,545
1931	2,023	3,297	5,320
1932	2,017	6,365	8,382
1933	2,290	8,374	10,664
1934	2,367	11,375	13,742
1935	2,251	11,434	13,685
1936	3,378	13,545	16,923
1937	3,816	16,620	20,436
1938	3,385	10,890	14,275
1939	2,278	9,095	11,373
1939—Jan.-Aug. ..	1,659	7,161	8,820
Sept.-Dec. ..	619	1,934	2,533

Spain is another country in which it has been proposed to start the manufacture of motor vehicles, though in this case the step would not have any material effect on British exports. Although the United Kingdom exported over 2,000 complete private cars and 125 chassis to Spain in 1935, exports have since declined very considerably as a result of the civil war, and amounted to only 32 private cars and two chassis in 1939. On the other hand, of course, lack of road transport, owing to the depreciation of vehicles during the civil war, constitutes one of the major problems in Spain, and British manufacturers of commercial vehicles might look forward to securing part, at any rate, of the replacement orders. The proposal to establish the industry in Spain took the form of an application by the Studebaker Corporation to set up a factory in the province of Vizcaya, with a production capacity of 4,000 vehicles per annum. It was proposed that the engines should be imported. Later in the year, however, it was announced that, as a long-term policy, the Spanish Ministry of Industry was proposing to establish a motor-vehicle industry with a capacity of 5,000 small cars, 9,000 large cars, 15,000 light and 1,000 heavy lorries, and 1,000 tractors. It was stated that the necessary subsidiary industries would be established during the next three years.

British exports of commercial vehicles up to the end of 1939 are shown in Table II, on this page. For the first four months of the war, exports of complete vehicles and chassis averaged 640 a month, compared with an average of 1,420 a month for the first eight months of 1939. A comparison of British exports and new registrations during the early months of 1940 suggests that production of private cars was probably at the rate of about 6,000 a month. This compares with about 30,000 a month during the early months of 1939 and a peak production of over 32,000 a month in 1937. The production of private cars for the home market had thus become only a subsidiary function of the industry, the main functions of which were the provision of trucks and lorries for the Army, and assistance to the aircraft industry. The change-over from peace to war-time conditions was apparently effected fairly smoothly, and, judging from the employment figures, at no time was any appreciable proportion of the resources of the industry unemployed. Separate employment figures for the motor industry are not available, but combined figures for employment in the manufacture of motor vehicles, cycles and aircraft are shown in Table III, on this page. By July, 1940, unemployment in this group of industries was reduced to 6,610, or about 1½ per cent. of the number insured at July, 1939. No figures have been published for the number insured at July, 1940, but there can be no doubt that a very large expansion took place during the year.

TABLE III.—*Employment in Construction of Motor Vehicles, Cycles and Aircraft.*

Year.	Number Insured.	Number Unemployed.	Number Employed.	Index. (1923 = 100.)
1923 ..	191,830	16,108	175,722	100·0
1929 ..	240,410	17,614	227,796	129·6
1930 ..	247,140	40,647	206,493	117·5
1931 ..	251,320	57,462	193,858	110·3
1932 ..	252,060	55,779	196,310	111·7
1933 ..	261,720	44,168	217,552	123·8
1934 ..	271,530	28,819	242,711	138·1
1935 ..	285,830	26,538	259,292	147·6
1936 ..	314,000	19,705	294,295	167·9
1937 ..	351,630	17,014	334,616	190·5
1938 ..	387,870	29,926	357,934	203·7
1939 ..	459,170	14,780	444,390	252·9
1940 ..	—	6,610	—	—

The export programme formulated after the outbreak of war provided for selling abroad during 1940 at least as many commercial vehicles as during 1939, and about 75 per cent. of the 1939 exports of private cars. The fulfilment of this programme would involve the shipment of about 11,000 commercial vehicles and chassis and nearly 50,000 private cars. As already stated, total exports during the first six months of the war averaged about 1,000 vehicles a week, or slightly less than the programme laid down. Bearing in mind, however, that this period covers the first two months of war, during which exports were exceptionally low, it would seem probable that, during the early months of 1940, the prospects of carrying out the programme appeared very good. Subsequent events, however, including the loss of many European markets and the ban on imports into Australia, must have caused a considerable reduction in exports. It would seem that the only way in which this decline can be made good is by increasing exports to the South American countries, and here, of course, British manufacturers meet the full force of competition from the United States.

British manufacturers were interested in maintaining home sales mainly in order to keep down costs of production. Quite early in 1940, however, strong official pressure developed to stop production for this market altogether, mainly in order to conserve supplies of raw materials. As a result of the rising costs of material and labour, and the fall in output, most companies were forced to increase prices in February by about 10 per cent. In order to avoid further increases in price, motor manufacturers asked the Iron and Steel Control for increased allocation of steel. At that time, it is understood, manufacturers were guaranteed all the steel supplies that they required for export for a period of five months ahead, but, for the home market, they were getting rather less than half their requirements, and this was guaranteed only for two months ahead.

In July, the Ministry of Transport imposed a ban on sales of motor vehicles in the home market, pending a survey of the cars in the hands of dealers, with a view to determining whether or not these

were suitable for export. Originally it was intended that the ban should apply only to commercial vehicles, but, in fact, the only exceptions made were for motor cycles, and vehicles used solely for agricultural purposes. Later, when it was found that all but a few of the unregistered cars in the hands of dealers could be exported, it was decided to place a permanent restriction on sales of new motor vehicles and to allow only persons engaged in work of national importance to have licences for the purchase of new cars. Incidentally, this measure should go a long way towards solving the problem of the growing number of secondhand cars coming on to the market. Not only will existing car owners be encouraged to keep their cars for a much longer period than usual, but, in addition, there are good prospects that dealers may succeed in selling a fair proportion of the large stocks of secondhand cars which they held on the outbreak of war.

In general, the ban on new sales was well received, since it was recognised as a necessary measure in order to conserve raw material supplies, and also to liberate skilled manpower for the production of munitions. The manufacturers' point that cessation of production for the home market must be accompanied by increased costs of production may have to be met, however, by the allocation of some form of subsidy for export sales.

Undoubtedly, the distributive and servicing side of the motor industry has been more heavily hit by the war than the manufacturing side, with the possible exception of certain small firms manufacturing parts and accessories. The manufacturing resources of the latter firms should, of course, be able to find employment on war work of one sort or another, but in practice this has often proved difficult. In this connection, an interesting development took place towards the end of the past year. About forty of the smaller motor-engineering firms in the West of Scotland combined to form the Scottish Engineering Group, Limited. The individual firms, since the outbreak of war, had found considerable difficulty in obtaining suitable work for their plant, because in only a few cases were they able to undertake contracts of sufficient volume to interest the Ministry of Supply and the main armament contractors. It is intended that the parent company, after surveying the resources available within the Group, shall arrange contracts with the Government or with main contractors and then allocate production to individual members of the group.

Many small engineering firms and garages, however, have been unable to obtain sufficient work. In June, an appeal for consideration of the potentialities of such firms was made by the chairman of the Motor Trade War Executive, which represents 15,000 retail motor traders throughout the country and was formed from the Joint Committees of the Motor Agents' Association and the Scottish Motor Trade Association. It was pointed out that, in the early days of the war, the Minister of Supply arranged with the Motor Agents' Association to nominate repairers to repair Army vehicles in various parts of the country. In the early part of the year, during the period of active warfare on the Continent, repairs to damaged vehicles provided a fair volume of work for the appointed firms, but the great majority of the trade did not participate in this work. There appears to have been a belief that garages should stand by in case of emergency, and have their organisations intact to repair and service Army vehicles. While waiting for such an emergency, however, there is little doubt that much machinery and skilled labour has been largely idle. There seems to be a good case for further grouping on the lines of the Scottish Group mentioned above. There are, undoubtedly, real difficulties in harnessing a large number of small firms to the war effort, and the loss of time involved in negotiating and co-ordinating all the small contracts which would be involved in employing such firms individually is a very real difficulty. On the other hand, groups, if formed, should not be too large, as it is important that the negotiating authority for each group should have a really thorough knowledge of the resources available to each member of the group.

On the retail side, the reduction in the sales of new vehicles has resulted in an appreciable fall in turnover of most of the firms in the industry, though this fall has probably been very much less than was anticipated at first. Immediately after the outbreak of war, a number of factors, of which the most important were the increased horse-power tax, the rationing of petrol and the general reduction of income levels, induced large numbers of people to lay up or even to sell their cars. During the winter of 1939-40, about 500,000 cars were laid up—approximately a quarter of the total number in use. Many of these, however, were put back on the road in the spring, and for the quarter ended June 30, 1940, receipts from motor-vehicle taxes were 850,000*l.* higher than for the corresponding quarter of 1939. This must be considered very satisfactory, especially in view of the increased rate of tax.

In the first few weeks of the war, values of secondhand cars declined sharply and there were few purchasers either of new or second-hand vehicles. Many dealers, who had not sufficient capital to buy secondhand cars at low prices and hold them until prices should recover, were faced with the prospect of closing down. Since then, the demand for secondhand cars has improved considerably and prices have risen sharply owing to the ban on new sales. One year-old cars, in many cases, are selling at prices little below the nominal price of a new vehicle of the same make. In addition, various Government Departments have been buying cars for conversion to ambulances, while vehicles have also been required for conversion by the auxiliary fire services. There seems to be little prospect of new cars being released on an increased scale for some time, so that values should continue to appreciate. The maintenance of sales of secondhand cars, however, probably depends more on the continuance of the present level of petrol rations and allowances than on any other factor.

Cycles and Motor Cycles.—It is impossible to estimate with any degree of accuracy the production of pedal cycles or of motor cycles during the past year. The exceptional demand for pedal cycles which was noted on the outbreak of war has probably declined somewhat, but demand has continued to outstrip production. This is due mainly to the reduction of output for the home market, on account of the necessity for conserving raw material supplies. It has been pointed out that production for the home market is now fixed in proportion to export sales, and home supplies are delivered to dealers in strict rotation. There is thus no direct link between production and home

TABLE IV.—*United Kingdom: Exports of Pedal Cycles.*

Monthly Average.	Number.	Index. (1913 = 100.)	Value.	Index. (1913 = 100.)
1913	12,303	100·0	50,790	100·0
1931—				
1st Quarter ..	15,088	122·6	54,272	106·9
2nd ,, ..	16,349	132·9	60,600	119·3
3rd ,, ..	12,136	98·6	43,234	85·1
4th ,, ..	14,477	117·7	46,287	91·1
1932—				
1st Quarter ..	12,860	104·5	44,705	88·0
2nd ,, ..	14,335	116·5	48,302	95·1
3rd ,, ..	11,390	92·6	34,499	67·9
4th ,, ..	14,693	119·4	42,213	83·1
1933—				
1st Quarter ..	14,943	121·5	43,771	86·2
2nd ,, ..	13,820	112·3	40,141	79·0
3rd ,, ..	16,786	136·4	47,824	94·2
4th ,, ..	23,457	190·7	63,195	124·4
1934—				
1st Quarter ..	18,951	154·0	53,914	106·0
2nd ,, ..	22,314	181·2	62,171	122·2
3rd ,, ..	23,007	187·0	62,685	123·3
4th ,, ..	29,791	242·1	81,418	160·3
1935—				
1st Quarter ..	32,631	265·2	92,611	182·3
2nd ,, ..	30,525	248·1	88,486	174·2
3rd ,, ..	30,712	249·5	84,136	165·6
4th ,, ..	31,899	250·5	85,655	169·0
1936—				
1st Quarter ..	32,569	267·5	90,614	178·5
2nd ,, ..	37,952	309·0	103,652	201·5
3rd ,, ..	50,738	413·0	132,507	260·0
4th ,, ..	51,799	421·3	137,780	270·1
1937—				
1st Quarter ..	60,415	491·1	159,173	313·4
2nd ,, ..	71,384	580·2	195,310	384·5
3rd ,, ..	79,055	642·6	221,075	435·5
4th ,, ..	66,201	537·0	200,874	393·8
1938—				
1st Quarter ..	41,544	337·4	127,361	250·6
2nd ,, ..	46,381	376·3	138,437	272·6
3rd ,, ..	41,546	337·4	117,393	230·4
4th ,, ..	62,682	509·5	175,196	345·1
1939—				
1st Quarter ..	58,106	470·7	163,405	321·7
2nd ,, ..	60,393	490·7	169,457	333·6
July-August ..	52,669	428·1	149,310	294·0
September-December	38,715	314·7	112,467	221·4

TABLE V.—UNITED KINGDOM: EXPORTS OF MOTOR CYCLES AND PARTS.

	Complete Motor Cycles.				Parts.	
	—		Value.		Value.	
	Number.	Index. (1913 = 100.)	£	Index. (1913 = 100.)	£	Index. (1913 = 100.)
1913	1,404	100·0	61,106	100·0	18,111	100·0
1931—						
1st Quarter	2,739	195·1	119,608	195·7	67,442	372·4
2nd ,, ...	2,722	193·9	118,025	193·1	67,905	374·9
3rd ,, ...	1,213	86·4	48,671	79·7	46,043	265·3
4th ,, ...	943	67·2	37,566	61·5	41,761	230·6
1932—						
1st Quarter	2,346	167·0	89,678	146·8	48,792	269·4
2nd ,, ...	2,062	146·9	82,248	134·6	55,738	307·8
3rd ,, ...	1,026	73·1	37,925	62·1	32,602	180·0
4th ,, ...	980	69·8	35,821	58·6	29,465	162·7
1933—						
1st Quarter	1,767	125·9	65,703	107·5	39,321	217·1
2nd ,, ...	1,840	131·1	69,269	113·4	43,623	240·9
3rd ,, ...	1,030	72·3	38,306	62·7	35,558	196·3
4th ,, ...	1,162	82·8	46,527	76·1	31,277	172·7
1934—						
1st Quarter	1,486	105·9	59,502	97·3	43,262	238·9
2nd ,, ...	1,668	118·7	65,473	106·9	47,561	262·6
3rd ,, ...	917	65·3	34,866	57·0	36,846	203·4
4th ,, ...	1,428	101·7	56,491	92·4	33,104	182·8
1935—						
1st Quarter	1,651	117·6	65,669	107·4	33,884	187·1
2nd ,, ...	1,780	126·6	70,651	115·5	36,243	200·1
3rd ,, ...	1,014	73·8	39,249	64·2	25,922	143·1
4th ,, ...	1,560	111·0	58,411	95·8	18,828	103·0
1936—						
1st Quarter	1,841	131·0	73,628	115·5	22,896	126·5
2nd ,, ...	1,621	115·5	64,534	106·0	30,855	166·5
3rd ,, ...	1,367	97·0	53,589	87·7	25,637	141·5
4th ,, ...	1,991	141·8	74,719	122·3	25,503	140·8
1937—						
1st Quarter	2,116	150·7	84,811	138·8	27,124	149·1
2nd ,, ...	2,263	161·1	90,094	147·4	34,691	191·5
3rd ,, ...	1,699	121·0	65,093	106·5	30,055	165·9
4th ,, ...	2,373	169·4	102,201	167·3	26,027	143·6
1938—						
1st Quarter	2,142	152·6	90,874	148·6	24,315	134·3
2nd ,, ...	2,074	147·8	84,921	139·0	35,939	195·2
3rd ,, ...	1,021	72·7	39,820	65·1	25,466	140·3
4th ,, ...	1,353	96·4	54,719	89·5	20,784	114·5
1939—						
1st Quarter	2,185	155·6	95,527	156·1	28,934	159·8
2nd ,, ...	2,132	151·8	87,202	142·7	39,845	220·0
July-August	1,614	115·0	66,416	108·7	33,196	183·3
September-December ..	692	49·3	29,874	48·9	15,970	88·2

demand, and several complaints have been made of the scarcity of new cycles.

As regards exports, progress in the early months of the war was not unsatisfactory. As shown in Table IV, opposite, exports for the period September to December, 1939, averaged 38,715 cycles a month, valued at 112,467*l.*, compared with 66,201 cycles, valued at 175,196*l.*, in the fourth quarter of 1938. No figures are available for 1940, but in October, 1940, it was announced that the Bicycle War Export Group was organising for the export within the next twelve months of 1,250,000 cycles, either complete or in component parts. It is not possible to compare this figure directly with exports in previous years, because the number of cycles exported in the form of parts is not known. In 1938, however, when 576,458 cycles were exported, valued at 1,675,160*l.*, the value of parts and accessories exported was 1,576,675*l.* It seems probable, therefore, that the programme for 1941 will cover between 600,000 and 700,000 complete cycles, and the balance will be in the form of parts. This would be slightly higher than the exports actually made in 1939, when 614,535 complete cycles were exported. It is hoped, particularly, to expand exports to South America, which formerly took a number of German and Italian cycles.

Motor cycles, as already pointed out, were excluded from the ban on sales of motor vehicles, imposed in July. Up to August, 1940, home sales were at the rate of about 3,000 a month, compared with rather over 5,000 a month in the previous year. A very significant feature of the sales during 1940, however, was the high proportion of the total accounted for by motor cycles of less than 150-c.c. capacity. These have consistently accounted for between 70 per cent. and 80 per cent. of the total sales, whereas, for 1939, the corresponding proportion was only about 25 per cent. As pointed out in this series in previous years, this is a class of machine to which, in the past, British manufacturers have not devoted a great deal of attention. German firms, however, achieved considerable success in export markets in this category, and it is to be hoped that the impetus given by petrol rationing to the development of the small machine in this country will assist British exporters to meet foreign competition at the end of the war. Since August, there has been a considerable decline in new registrations, which amounted to just under 1,900 in September and October, and only 917 in November. This decline may have been due largely to seasonal factors.

United Kingdom exports of motor cycles declined sharply on the outbreak of war, as shown in Table V, opposite. Average exports for the four months September to December, 1939, were 692 machines a month, valued at 29,874*l.* This compares with a monthly average of 1,353 machines, valued at 54,719*l.*, in the fourth quarter of 1938. Exports of parts, however, held up better, averaging 15,970*l.* a month for the first four months of the war, compared with 20,784*l.* in the fourth quarter of 1938.

AMERICAN OIL INDUSTRY.—The production of crude oil in the United States, during the week ending December 28, 1940, averaged 3,385,000 barrels per day, this figure representing a decline of 235 700 barrels from the preceding week's total.

THE NITRIDING OF AERO-ENGINE CYLINDER BARRELS.—A large battery of nitriding furnaces has recently been placed in service at the Paterson Works, New Jersey, U.S.A., of the Wright Aeronautical Corporation. According to *The Iron Age*, the plant consists of seven 150-kW electric furnaces capable of treating 2,500 aero-engine cylinder barrels every three days. Each furnace weighs 45 tons and can accommodate 5 tons of parts at one filling. The furnaces are mounted on rails and are drawn over sealed Nichrome-alloy receptacles, each of which has a capacity for 60 cylinder barrels. The process occupies 50 hours; during the first 10 hours the furnace and the charge are brought up to the correct temperature, and then follows a period of heating at 1,000 deg. F., for 30 hours. Finally, a period of 10 hours is allowed for the charge to cool sufficiently to permit the containers to be emptied. The hardening process is confined to the bore or interior wall surface, and, to prevent the exterior from being affected, this portion is plated with tin, which does not react with the nitrogen contained in the ammonia vapour employed.

THE ORIGIN OF GAUGES FOR WIRE, SHEETS AND STRIP.*

By DR. H. W. DICKINSON and HENRY ROGERS, M.B.E.

(*Concluded from page 75.*)

Standardisation in Great Britain.†—From the early part of the Nineteenth Century onwards, the field for the use of wire increased enormously and its manufacture was taken up by numerous firms. Each manufacturer may be said to have been a law unto himself. The necessity to obtain agreement among makers with regard to the numbers they attached to different sizes was realised. A few words must, therefore, be said about standardisation. There was a fundamental conflict of interests and ideas as to what a standard should subserve. Manufacturers and workmen whose trade, customs and payments were the outcome of existing sizes desired no change. Hard material like steel required, perhaps, four draws for one of iron to get the same reduction, bringing in closer sizing. With sheet metals and glass, weight per unit area was a basic requirement. For electrical wire, conductivity was one of the criteria. Holtzapffel, realising that standardisation of some kind was imperative, in 1847 made an examination of "the exact values of the principal gauges in use for sheet metals and wires, a subject he believes to have been hitherto overlooked." Based upon these values, he established a gauge comprising 40 numbers from 0·34 in. to 0·004 in. in diameter and this came into extensive use under the name of the Birmingham Wire Gauge (B.W.G.), for all but special kinds of wire. He published his results in tabular form in 1856. In the second place, he made "a proposal he has long desired to see carried out, namely, an easy and exact system of gauges for sheet metals, wires and general purposes, founded on the decimal division of the inch."

This was not taken up at the time, but, in 1857, Joseph (afterwards Sir Joseph) Whitworth took up the suggestion. He read a paper‡ on his proposed gauge in that year and said "The scale proposed for the wire-gauge commences with the smallest size and increases by thousandths of an inch up to half an inch. Contrary to the custom usually adopted in marking the wire-gauge, I have called the smallest size No. 1, being 1-1,000th of an inch, No. 2 being 2-1,000th of an inch, and so on; increasing up to No. 20 by 1-1,000th of an inch between each number; from No. 20 to 40 by 2-1,000th; from No. 40 to No. 100 by 5-1,000th of an inch. I propose, therefore, to suppress the use of the numbers of designation which have been hitherto employed for the various wire-gauges, and simply call the sizes by the expressive numbers in thousandths of an inch, as shown in the accompanying table of wire gauges; a change which will I think render the new scale easily intelligible and convenient for use." He named it the "Standard Wire Gauge"; it covered a range of 58 sizes of from 0·5 in. to 0·001 in. in diameter. In this gauge, in contradistinction to the B.W.G., increasing numbers meant increasing diameters; this gauge was stillborn and we cannot find that it was used. The use of the term "mil" for the thousandth of an inch is credited to James Cocker, of Liverpool, who adopted it in 1858.

Latimer Clark was another of those who attempted to bring order out of chaos. Assuming that the origin of the wire gauge was empirical, it will be seen that successive reductions of wire must have borne some relation to the areas of the wire, *i.e.*, to the square of the diameter. If they are plotted as a graph, we get a curve logarithmic in character. The corresponding graph of Whitworth's Gauge is, of course, a straight line. This was first observed by Clark in papers read by him before the British Association.§ He proposed that each size should increase in weight 25 per cent., or in diameter 11·8034 per cent.; his gauge numbers extended from 5/0 to 40. The British Association, however, did not take up the matter, and confusion still reigned. We incline to the opinion that Clark was right and that the empirical gauge is, after all, the scientific one for wire.

Standardisation appeared to be as far off as ever. At one time there existed no fewer than 55 sets of gauges, 45 of which were for wire manufactured and used in the United Kingdom; some 28 of these purported to be B.W.G. Makers differed from each other in the diameters they attached to particular numbers and were not even consistent with themselves over a long period of time. Hughes gives a vivid picture of the confusion caused, the consequent trickery that was practised, and the resulting loss to merchants, all of which was at its height when he wrote in 1879.

The use had grown up, meanwhile, of particular gauges for particular forms of wire, such as pinion wire, music wire for pianofortes, and needle wire (all of steel), wood-screw wire, also gauges for sheets, hoop iron and tinplates. These gauges went, and still go, under the names of Lancashire, Stubs, Rylands, Warrington, South Staffordshire, etc. A further cause of confusion was that France, Germany and the United States each had one or more gauges of their own. Agitation by the more far-seeing manufacturers and merchants resulted in the Associated Chambers of Commerce appointing a Wire Gauge Committee, which conferred with the persons above-mentioned and others. Their report, issued in 1881, was subjected to criticism by the local Chambers of Commerce and this culminated in July, 1882, in the submission to the Board of Trade of a proposal for statutory standardisation. After counter proposals by the Board, substantial agreement was reached. The Imperial Standard Wire Gauge (I.S.W.G. or S.W.G.), based largely on the B.W.G. but with closer sizing and extension up to 7/0 (0·5 in.) on the one hand, and No. 50 (0·001 in.) on the other, was declared to be a legal standard under the Weights and Measures Act, 1878, by Order in Council dated August 23, 1883, which came into force on March 1, 1884. Although the B.W.G. is obsolete, it dies very hard and still persists in out of the way works; as might be expected, the same discrepancies occur as in Hughes's day.

A production gauge that should be mentioned is the Birmingham Metal Gauge, now almost obsolete except that it still appears on the trade cards and lists of metal rollers, for the convenience of customers who still use it. The gauge runs the reverse way of the I.S.W.G. and wire gauges generally, *i.e.*, from No. 1 (0·008 in.) to No. 40 (0·300 in.); metal rollers produce strip thinner than No. 1 and, to provide for this, No. 1/0 (0·007 in.), No. 2/0 (0·006 in.), No. 4/0 (0·005 in.), No. 6/0 (0·004 in.), and No. 8/0 (0·003 in.) were added. One of the authors has seen it stated that the thinnest gauge is No. 11/0 (0·0015 in.) but he has not gone beyond No. 8/0.

The need for standardisation was experienced equally in the United States as here. In 1895, a Joint Committee of the American Society of Mechanical Engineers and the Master Mechanics' Association agreed to recommend the use of the decimal gauge, thus reverting to Holtzapffel's and Whitworth's ideas. They recommended "the abandonment and disuse of the various other gauges now in use as tending to confusion and error." Other American gauges are Brown & Sharpe's, Roebling's or Washburn and Moen's, Trenton Iron Company's, and the Morse Twist Drill and Steel Wire Gauge. Another gauge used in the United States is the Edison or Circular Mil Wire Gauge for electrical work. The Edison companies experienced inconvenience and loss through not having a wide enough range or a sufficient number of sizes in existing gauges. The engineering branch of the companies designed a gauge, the basis of which is the sectional area: thus, a wire of a 10,000 circular mils area is No. 100, a wire of half the area is No. 50, and so on. The range is from 3 (3,000 circular mils) to 360 (36,000 circular mils). The conductivity of the wire is known from its number, on the assumption that the wire is of standard copper.

In France there have been a number of gauges, such as the Jauge de Limoges, and the Jauge de Paris, 1857. The latter was most used and is not quite obsolete, but has been superseded by the millimetre gauge, which like the Whitworth, is a decimal one. In March, 1895, the Ministère de Marine adopted this gauge officially. In it the numbers run from 100 to 6, each number representing a diameter in mm. $\times$ 0·1, *i.e.*, No. 100 equals 10 mm., and so on. This gauge is also in use in Germany. In the latter country, other gauges, such as the Westphalian Common W.G., 1877, are in use. Nowadays, owing to the fact that the micrometer is everywhere available, it has become increasingly usual for the consumer to specify the actual diameter of the wire in mils and dispense with the notch gauge.

When the I.S.W.G. was legalised in 1883, it is clear that it was expected officially that it would cover every case that could be measured with a notch gauge, but such did not prove to be the case. For strip and sheets, many of the intervals between numbers are too wide. Hence the sheet and hoop-iron trade, being quite distinct from that of wire, did not adopt the I.S.W.G., and a "South Staffordshire" gauge, based on practice in that area, was adopted immediately after 1884; a generation was spent in controversy and correspondence about it. Harry Skelton, Watson Stack, and James Whitby, with the backing of the London Chamber of Commerce, recommended to the Board of Trade, in 1912, the legalisation of the "Birmingham Gauge" (B.G.), which is, in substance, the

* Paper presented to the Newcomen Society, January 15, 1941. Abridged.

† For much of the material in this part of the paper the authors are indebted to Mr. W. A. Young, who gave the story in detail in *The Ironmonger Diary* for 1915. Cf. also *The Ironmonger*, May, 1937.

‡ Papers on Mechanical Subjects, *Proc. I. Mech.E.*, 1858.

§ "On the Birmingham Wire Gauge," by Latimer Clark, M.Inst.C.E., *Trans. Brit. Assoc.*, 1867; "On the Advisability of Obtaining a Uniform Wire Gauge," by Latimer Clark, M.Inst.C.E., *Trans. Brit. Assoc.*, 1868.

THE MANUFACTURE AND USE OF CEMENTED CARBIDES.

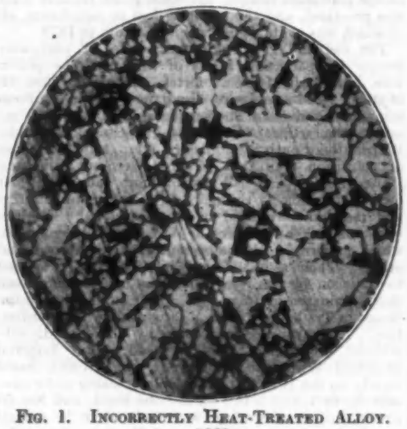


FIG. 1. INCORRECTLY HEAT-TREATED ALLOY. × 1000.

FIG. 2. EUTECTIC COMPOSITION. × 1500.

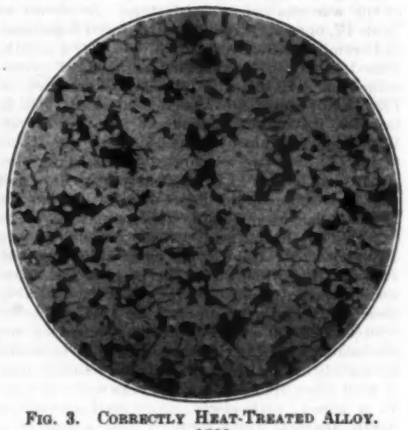


FIG. 3. CORRECTLY HEAT-TREATED ALLOY. × 1500.

South Staffordshire Gauge; and an Order in Council was made on July 16, 1914, coming into force on November 1 of that year, making it a legal standard. The B.G. starts at 15/0 (1 in.) and ranges to No. 52 (0·00095 in.).

The need for the standardisation of sheets was felt in the United States almost as early as it was over here. The "Standard Gage" for iron and steel sheets was established by Act of Congress and came into force on July 1, 1893. This is based on the principle, already mentioned, of weight per unit area. It rests on the assumption, near enough for practical purposes, that a cubic foot of wrought iron always weighs 480 lb. Each descriptive number represents the number of ounces in weight of a square foot of iron of that number of 4-100th of an inch in thickness. The numbers run from 7/0 (0·5 in.) to 38 (0·0063 in.).

Nowadays, as in the case of wire, large consumers order sheet and strip by decimal parts of an inch, and can obtain their requirements because the micrometer is in regular use by up-to-date rolling mills. As an illustration of the use of gauges in the rolled-metal trade, chiefly brass and copper, the experience of one of the authors during the years 1880-1900 may be mentioned: (*a*) In first rolling operations, the S.W.G. is used, No. 13 (0·092 in.) thick. (*b*) In the second and intermediate rolling operations, the B.G. is used from No. 24 (0·91 in.) downwards. (*c*) Finishing-rolling operations are measured by micrometer for any thickness down to 0·003 in., whether ordered by S.W.G., B.G., millimetre gauge, or by weight. Old customs die hard. The consumer may and does order by S.W.G. or B.G., but the manufacturer works to decimals of an inch. All the same, the invoice states the S.W.G., or the B.G., and not the decimal size supplied.

THE MANUFACTURE AND USE OF CEMENTED CARBIDES.*

By H. BURDEN, B.Sc.

THE basis of all cemented-carbide cutting-tool alloys has been, and still is, tungsten carbide. It was discovered by Moissan during his researches with the electric furnace in 1886, and he described it as a black, lustrous, hard, brittle and coarsely-crystalline compound. For 30 years the material remained a curiosity, and this is not surprising. I have prepared carbide by Moissan's method, and if such a product be compared with the cemented carbides used to-day, it is doubtful whether the two materials would be associated. The work on this compound was revived when a substitute was wanted for diamonds for wire drawing, particularly for the manufacture of tungsten filaments, and it was natural that tungsten carbide should be tried. Made in the modern way, tungsten carbide has entirely different properties from the Moissan product, and a further improvement has been effected by the addition of what is now known as a "bond metal," which gives the material a degree of toughness. The process was developed in Germany and very soon afterwards in the United States, where a great deal of attention was paid to carbides of metals other than tungsten. The first hard metals, containing tungsten carbide and cobalt, are still most generally used, and constitute the bulk of the commercially-produced hard metals. While a number of other metals, such as tantalum and titanium, are employed, they are used chiefly in small percentages as addition elements to the tungsten carbide-cobalt hard metals.

There are two methods of manufacture—the cold-press and the hot-press processes. The latter, however, is no longer used, the cold-press method being that almost universally adopted. In this method the tungsten is first converted into carbide. This carbide is then broken down by crushing, and is intimately mixed with cobalt in a ball mill for a predetermined period. The resulting mixture is an exceedingly fine powder, which is pressed into blocks of suitable size and shape for the production of tool tips. The pressing is done in hardened steel dies at pressures which vary considerably, from as little as 3 tons to as much as 100 tons per square inch. Although these blocks may be handled quite readily at this stage, they require some shaping to their final form, and it is desirable that further toughening be carried out before this shaping takes place. Usually a semi-sintering operation is carried out. This is accomplished by heating the blocks in a reducing atmosphere, such as hydrogen, to the pre-sintering temperature. The blocks of the material at this stage have the consistency of chalk or graphite, and may easily be cut to shape; they are sufficiently strong to be handled with ease and to enable sharp edges and definite forms to be given to them. The shaping is carried out on abrasive wheels on special machines, after which the blocks, which are now in the form of shaped tool tips, are ready for sintering. It is essential that the tips should be shaped to within fairly close limits of their intended dimensions since, after final sintering, grinding is the only method of altering the form.

The tips are now placed carefully in refractory crucibles and are subjected to a critical high temperature for a time which may vary from 15 minutes to two hours, depending on the properties required of the alloy. The rate of heating to, and cooling from, the sintering temperature affects the products, and in all cases is precisely controlled to give definite characteristics. After this heat treatment the tips are ready for use. Many variations of this process have been devised to overcome some of the inherent difficulties which occur and to produce materials with modified characteristics. For instance, in the manufacture of an alloy containing only 3 per cent. cobalt and 97 per cent. tungsten carbide, it is extremely difficult to ensure the even distribution of the cobalt. One method, which has been proposed to accomplish this, is to electroplate the carbide particles with cobalt metal, while another is to add the cobalt in the form of oxide or similar compound, which, after being evenly mixed with the carbide, is reduced to metal by the application of heat in a reducing stream of gas. Such modifications as these give desirable characteristics in certain cases, but for the greater part the process is carried out as outlined above.

The Nature of the Constituents.—As has already been indicated, two essential phases are present, namely, an intensely hard one and a soft ductile metal, and for our purpose we can consider these two to be tungsten carbide, on the one hand, and cobalt, on the other. The properties of cobalt are, of course, well known. It is a ductile metal of the iron group, and in the pure state possesses a high tensile strength. Its melting point is 1,480 deg. C., and, as far as can be judged from the work so far carried out, it appears that cobalt does not form a carbide. W. P. Sykes has determined the constitutional diagram of the tungsten-carbon system, from which it appears that the carbide is formed by a peritectic reaction at 2,600 deg. C. The hardness of tungsten carbide cannot yet be said to have been finally determined, but, in a paper by Ridgeway, Ballard and Bailey, it is stated to have a hardness equivalent to that of fused alumina.

According to data prepared by Dr. W. H. Hatfield, F.R.S., the hardness of pure tungsten carbide may be not less than, and may even materially exceed, a diamond-pyramid hardness value of 2,200. Thus, it may be concluded that the hard constituent of the cemented carbides has a hardness greater by 1,000 points on the diamond hardness scale than the hardest steel that can be made.

Structure.—The structure of a cemented carbide consists of hard particles bonded together in a matrix of cobalt, and the micro-photograph shown in Fig. 1, on this page, gives a clear idea of what it is like. The particular specimen reproduced here is very coarse-grained compared with most cemented carbides. The dark phase is the cobalt matrix.

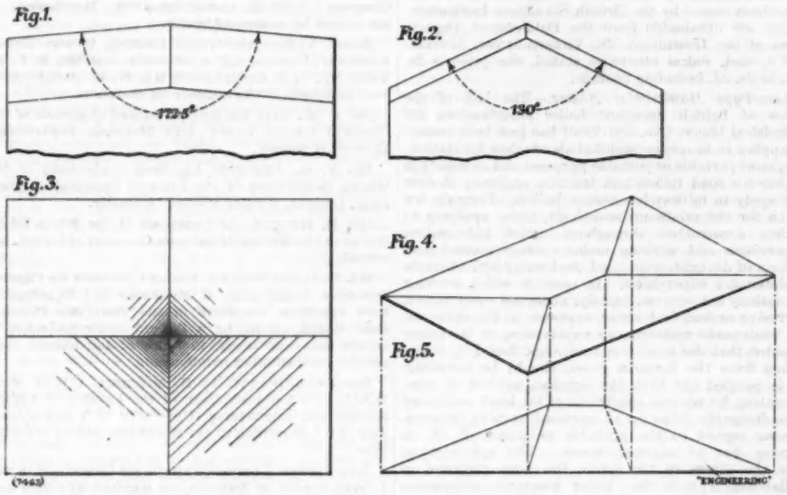
The Sintering Process.—The sintering process in the case of cemented carbides does not consist merely of a welding together of the particles of the pressed powder, and a more descriptive term, namely, "fritting," has been suggested by Dr. Jones. It has been established that tungsten carbide and cobalt react to give a very complex system, and this has been investigated by Takeda, the Japanese worker. The most noteworthy point in his equilibrium diagram is the formation of a binary metastable eutectic containing about 34 per cent. cobalt. Thus the sintering or fritting operation may be said to take place in its simplest manner in the following way:—On heating the mixture of cobalt and tungsten-carbide powders, some limited diffusion takes place with the formation of solid solutions. At the eutectic temperature, some of these solid solutions melt and "wet" the remaining particles. Hence, a pasty half-molten mass is produced. If the temperature is further increased, more of the tungsten carbide dissolves in the cobalt to form an increasing amount of liquid. On cooling, the tungsten carbide is thrown out of solution to form angular grains, which are clearly evident in the microphotograph shown in Fig. 1. Finally, the remaining liquid solidifies at the eutectic temperature to form the matrix which bonds the hard particles together.

The eutectic, however, never forms with a "herring-bone" structure in the commercial alloys, since one phase, the tungsten carbide, is always precipitated on the main bulk of undissolved grains of tungsten carbide. This leaves a solid solution as the bond, and, on cooling down to room temperature, this solid solution throws out tungsten carbide, to leave almost pure cobalt as the bond. Thus, in spite of the complicated sequence of the reactions, the material finishes up as two almost pure constituents, soft cobalt, on the one hand, and intensely-hard carbide, on the other. The eutectic which has been referred to is shown in Fig. 2, above, while Fig. 3, on this page, illustrates the microstructure of a correctly-sintered cemented carbide. The magnification at which this micrograph was taken should be noted.

The sintering process, in actual practice, is not quite so simple as may have been gathered from the foregoing remarks. Thus, grain size may vary within wide limits if not controlled. Graphite may be precipitated

* Contribution from the Brown-Firth Research Laboratories, read before the Institution of Production Engineers, at Sheffield, on April 22, 1940. Abridged.

DIAMOND POINT FOR HARDNESS TESTING.



if the material is not held in the metastable condition, while the rate of cooling may be such as to hold in solution, in the cobalt, an undesirable amount of the hard constituent, and thus increase the effective percentage of bond metal present. In practice, it is found necessary to control the rate of heating, the time at the sintering temperature and the rate of cooling if the desired characteristics are to be obtained. In addition, changes can be effected by varying the proportions of the bond metal and the hard carbide. Thus it has been found that the toughness, resistance to shock, and strength of the cemented carbides are increased as the proportion of the bond metal is increased, while brittleness, increased hardness, and wear resistance is obtained by lowering the bond-metal content.

Steel-Cutting Carbides.—So far, only tungsten carbide and cobalt have been dealt with as the hard carbide and bond metal, and while many other carbides have been investigated, no others have been so universally used. As has already been indicated, other carbides are chiefly useful as additions to tungsten carbide-cobalt alloys to impart to these materials special properties. Of these carbides, only those of titanium and tantalum are employed to any great extent. The field of application for these special carbides is, generally speaking, the cutting of steel as distinct from the cutting of cast iron and non-ferrous metals. It is found that all tungsten-carbide alloys very rapidly develop a chip cavity on the upper surface of the tool. This increases the effective top rake of the tool to such an extent that failure of the tool is very rapidly brought about. When titanium carbide and tantalum carbide are added, however, it is found that this cavitation does not take place. The reasons for this are somewhat obscure, and, while theories have been suggested which seem quite reasonable, there is room for further work on the subject.

The view popularly held is that the hot steel cutting, as it passes over the upper face of the tool, actually welds on to individual grains of carbide. This results in the removal of a succession of particles, which soon leads to the development of a cavity. This explanation also accounts for the fact that the cutting edge of the tools may remain unmarked while the cavity is growing. Another theory postulates that the formation of the cavity is due to the different heat conductivity of the two types of material; while yet a third suggests that the surface of the straight tungsten carbide is rough, even in the most highly finished state which it is possible to produce commercially. It is, however, a fact that alloyed hard metals do resist chip-cavity formation to a remarkable degree, and where conditions are suitable it is now possible for a carbide tool to work for longer periods on steel than it will on cast iron.

In the early development of the steel-cutting carbides great difficulty was experienced, and still is with some types of carbide, owing to brittleness, which is always associated with them. The cobalt content, for special reasons, has to be kept within narrow limits, and it is not possible to vary the hardness and toughness so readily as with the straight tungsten carbide-cobalt alloys. Recent work, however, has shown that this disadvantage may, to a large extent, be overcome, and the successful machining of rough forgings, for instance, where the property of resistance to shock is of primary importance, is now an accomplished fact. Nevertheless, great care must be taken that the correct grade of carbide is used for this type of work.

The manufacture of the tools from the carbide tips has been well described in the literature published by the manufacturers of this type of product, and very little remains to be said. As is well known, the carbide is used in the form of tips brazed on to carbon-steel shanks. The brazing may be equally well done with copper, spelter, silver solder or similar compounds. No special care is necessary other than preventing rapid temperature changes of the hard metal during the operation. For normal purposes, the carbon content of the steel shank should be about 0·5 to 0·6 per cent., but this composition is not essential. When brazing these tools the braze metal, between the shank and the tip, need not be limited to a thin wall; on the contrary, a reasonable thickness of braze metal tends, to some extent, to absorb the stresses caused by the differential rates of contraction of the carbide and the shank material when cooling from the brazing to the room temperature. In fact, such procedure as the insertion of iron gauze and molybdenum sheeting has been resorted to, in order to ensure that a sufficient cushion of braze metal is left underneath the tip. The fabrication of special tools, such as reamers, inserted-tooth cutters, milling cutters, counter bores, and drills is best left to the makers of carbide alloys. On the other hand, there is very little difficulty in the building up of ordinary turning tools, and any shop may undertake this work with confidence, provided that the necessary care is taken.

Carbide manufacturers and manufacturers of grinding wheels have collected and published a large volume of literature relating to the grinding operation. There does seem, however, to be one feature which has not been exploited to its fullest extent, and that is the use of diamond grinding wheels. There is no doubt that the most economical method of reconditioning tools which have not been very badly damaged is by the use of a diamond wheel. It is only when a badly chipped or broken tool has to be re-ground that the coarse silicon-carbide grinding wheel offers any advantage over the diamond. Wherever the volume of work is sufficient, the diamond wheel affords the cheapest method of tool reconditioning with one exception, namely, the grinding of forms on form tools. Since the diamond wheel cannot readily be shaped by any normal method, it is often better to use silicon carbide wheels for this work.

The Application of Carbide Alloys.—The successful application of carbide alloys depends almost entirely on the correct selection of the type of carbide for the work required. No single tool or tool material will work equally well in all circumstances, and this is particularly true of carbide hard metals. Many shops to-day use only one or two grades, say, one for cast iron and non-ferrous metals, and one for steel cutting, whereas there are, in fact, many different types and grades available. While in certain cases this may be the most economical arrangement, it is certain that in many shops a saving could be effected by a close investigation of this question of the correct grade for each specific set of conditions.

Before describing the application of different grades to the type of work met with in industrial practice, it may be of some interest to consider further the peculiarities of the physical properties of carbide tools in relation to the work which they have to perform. The actual hardness range of the cemented carbides has been investigated by Dr. Hatfield, and he has shown that the value of the hardness, on the diamond scale, varies from about 1,300 for the soft, tough alloys, containing large percentages of cobalt, to about 1,700 for the harder alloys which have been developed for such arduous work as the drilling and machining of glass, porcelain, etc. When greater hardnesses are required, there are experimental types available which have given diamond-hardness values well in excess of 2,000. A no less important factor is that cemented carbides retain their intense hardness at elevated temperatures in a most remarkable manner.

Such properties enable carbides to machine many materials which cannot be dealt with by any other tool. Examples of this are the machining of glass and porcelain, to which allusion has already been made, and stone, slate, and even hardened tool steel itself. Further, the retention of hardness at high temperatures enables extremely high cutting speeds to be maintained. This extreme hardness is, however, accompanied by a rigidity which does not allow the material to absorb a great deal of shock before fracture takes place, and this point must be remembered when using the tools. They cannot be applied in the same manner as high-speed steel tools, and it cannot be too strongly emphasised that, while the application of these alloys is not difficult, it does necessitate a different technique from that required by other cutting alloys. Coupled with this absence of resistance to shock is the fact that, in relation to the hardness, the tensile strength and the shear strength are low, and this again introduces difficulties. It is found that if the tools are put to work at slow speeds with heavy feeds rapid destruction often results, and it is essential for success that carbide tools be worked at high speeds with comparatively fine feeds. Under these conditions the actual pressure on the cutting edge of the tool and the material immediately behind it, are reduced to a safe level, and, to obtain the necessary increase in the rate of machining, advantage may be taken of the very high cutting speeds of which these tools are capable.

(To be continued.)

PYRAMIDAL DIAMOND POINT FOR HARDNESS-TESTING.

THE testing of the hardness of materials by their indentation with a hardened ball or diamond point has, it is common knowledge, proved a method of great value to the engineer, in spite of the fact that the indications obtained are merely relative and the scales arbitrary. The types of hardness-testing machine in use to-day, however, have certain limitations in some directions; for example, they are not suitable for testing the hardness of brittle materials, of very thin surface films and the hardness differences in the microstructure of metals, these all calling for very shallow indentations. In other words, the machines, as generally fitted, are not sensitive enough for such special operations. The question of rendering them more sensitive is discussed by Messrs. F. Knoop, C. G. Peters and W. B. Emerson, in a paper entitled "A Sensitive Pyramidal Diamond Tool for Indentation Measurements," published in the *Journal of Research of the National Bureau of Standards, U.S.A.* A short summary of this paper is given below, and certain of the illustrations are reproduced in the accompanying Figs. 1 to 5.

The shape of the sensitive diamond is indicated in Figs. 1 to 3. It is pyramidal, but the four faces are inclined in such a way that the diagonals of the indentation are in the ratio of 7 to 1, as against the 1 to 1 of the quadratic diamond employed in the Vickers method. In the preliminary tests, eight different diamond points, between 0·25 carats and 1·5 carats, were used, the ratio of length to width of the indentation varying from 14·6 to 5·0, while the ratio of length to depth of indentation was from 49·1 to 24·7. These preliminary tests led to the tentative adoption of the shape shown in Figs. 1 to 3. From Figs. 1 and 2 it will be seen that the ridges of the four surfaces are inclined in the longitudinal direction to include an angle of 172·5 deg., and in the transverse direction to include an angle of 130 deg. These slopes give an indentation having a ratio of length to width of 7·11 to 1·0, and a ratio of length to depth of indentation of 30·5 to 1·0. The indentation contour is that of a much-elongated "diamond," using the term in its playing-card sense. In the plan of Fig. 3, an attempt has been made by graduated lines to indicate the slope of the four faces.

The sensitiveness of the point depends upon the large ratio of length to width of the indentation. Obviously, the tested material is stressed considerably in the region of the diameter across the width, since the included angle of the faces of the point is least

on this diameter, but this stress is relieved progressively towards the ends of the longitudinal diameter, a fact capable of proof when transparent materials are tested in polarised light. It is stated that brittle materials such as glass, dental plastics and enamels, and even diamonds, may be impressed with minute indentations without showing cracks. Observation has shown that the greater part of the elastic recovery of an indentation, after withdrawal of the indenting point, occurs in the transverse rather than in the longitudinal direction. As the deformation of the diamond point under load can be neglected, owing to its low modulus of cubic compressibility, namely, $5{\cdot}5 \times 10^{12}$ dynes per square centimetre, a close approximation to the unrecovered width, lateral or contact area, projected area, penetration and volume can be had from measurement of the length of the indentation. When the width is also measured, the recovered projected area may be determined with accuracy.

The readings are expressed as an indentation number, from the formula: $I = \frac{L}{A} = \frac{L}{l^2 \times c}$, where I = the indentation number; L = load on the point in kilograms; A = unrecovered projected area of the indentation in square millimetres; l = measured length, in millimetres; and $c = 0{\cdot}0703$, this figure being a constant for the standard shape of point. The relation of the hardness to the unrecovered projected area was made after careful comparative tests with numerous materials. The chosen relation has the advantage that in the result both the elastic and plastic deformations are expressed. The differences between different diamond points when testing different materials was found to be very small. It is claimed that a true correlation between the indentation number and the load can be found, in contrast to other relations based on the length of the indentation, its surface or volume. As regards the influence of the load on the indentation number, a number of tests, made with a point differing only slightly from that shown in Figs. 1 to 3, showed that the numbers were nearly constant except at low loads, for a wide variety of materials. The measured lengths of indentation were all in excess of 0·1 mm. As to the relation of the indentation number with commonly-used hardness numbers, tests showed that they differ slightly from the Brinell and Vickers numbers. An indentation number of 600, for example, will have a corresponding Vickers number of 606 and a corresponding Brinell number of 578. The higher Brinell numbers involve the employment of balls of cemented tungsten carbide.

The loading range for the new point is from 0·1 kg. (0·22 lb.) to 2 kg. (4·4 lb.). For loads up to 0·5 kg. (1·1 lb.) a special testing instrument has been designed, but for higher loads the usual hardness-testing machines are used. The surfaces of the specimens used in the tests were polished and lapped and were free from scratches. In the preliminary tests, the test speed was varied between the rates of 36 mm. and 1 mm. per minute. The main tests were carried out with a standard speed of 18 mm. per minute. The contact period ranged in the preliminary tests between 10 seconds and 4 minutes, but, as no change in the indentation number occurred in the more resistant materials after a contact period of 20 seconds, this duration has been selected as the standard time for all materials. The diamond points are cut by means of a special apparatus and technique. The cut diamonds have plane faces which intersect in edges that appear straight and free from even the most minute serrations when viewed with a magnification of 75 diameters. The points can be duplicated with an exactness sufficient to give reasonably consistent results on a given material, and the angles can be readily measured to give the required degree of accuracy. It is stated that little wear seems to take place in use, there being no discernible wear after two years' service in the investigations described above.

As a matter of interest, attention may be drawn to the alternative form of diamond point suggested by Mr. Knoop and illustrated in Figs. 4 and 5. This point has been made and patented, but was not used in the tests described above. From the plan, which is in true projection and is not an isometric view, it will be seen that the point has a rhombic base, and four inclined asymmetrical faces. This shape does not result in a single apex as do the pyramidal diamonds, but in a ridge of considerable relative length, the whole shape suggesting a distorted hipped roof. Presumably, this design is intended to distribute the stresses on the indented material more evenly, but it is yet too early to assess its value relative to the point shown in Figs. 1 to 3.

EXPORT CREDITS GUARANTEE DEPARTMENT.—It is announced that, under the Export Guarantees Act, 1939, the Exports Credits Guarantee Department assumed liability up to a maximum of 8,737,507*l.* in respect of contracts, policies and guarantees amounting to 16,899,736*l.*, during the quarter ending December 31, 1940.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Loco-Type Multitubular Boilers.—The last of the series of British Standard boiler specifications for cylindrical boilers (No. 931-1940) has just been issued. It applies to loco-type multitubular boilers for stationary, semi-portable or portable purposes and to loco-type boilers for road rollers and traction engines; it does not apply to railway-locomotive boilers. Formulæ are given for the minimum scantlings, these applying to boilers constructed throughout under independent supervision and working under average normal conditions of draught, with good feed water and adequate maintenance supervision. In cases in which working conditions are adverse, namely, abnormal evaporation, corrosive or bad feed water, exposure to the elements, or inadequate maintenance supervision, it is recommended that the minimum scantlings, found by calculation from the formulæ given, should be increased. It is pointed out that the simplest method of compensating for adverse conditions of the kind mentioned is to design the boiler for an increased working pressure, having regard to the probable reduction of life in service due to adverse causes. The specification, like the others in the series, has been prepared in collaboration with the boiler insurance companies, boilermakers, users, and the classification authorities. Full details concerning technical requirements relating to construction and workmanship are included. [Price 3*s.* 6*d.* net, or 3*s.* 9*d.* including postage.]

Oils, Thinners, Pigments and Paints.—Many materials normally used in the paint industry have to be imported, and the Government has found it necessary to prohibit, or restrict, their use in order to relieve demands on shipping and to conserve currency. This has necessitated a complete review of the series of specifications dealing with paint materials, culminating in the issue of new war-emergency standards Nos. 925 to 929-1940. No. 925 and 926, published under one cover, relate, respectively, to oil, thinners and driers for paints, and to additional mineral extenders for paints. Nos. 927 and 928 are also issued together in one publication. No. 927 deals with alternatives for lead and zinc chromes, and No. 928 with alternatives for Brunswick or chrome greens and green oxides of chromium. The last specification, No. 929, relates to ready-mixed priming, undercoating and oil-gloss finishing-coat paints. Where necessary, the existing requirements of these specifications have been relaxed so as to allow the use of material of lower standard quality, and, in addition, the use of alternative materials has been provided for. The alternative materials, for the most part, are home products. It is emphasised, however, that the modifications made, and the substitute materials suggested, in no way affect the existing specifications which are retained to provide standards for materials for export. On the other hand, it is directed that the war-emergency specifications should always be employed for materials for home consumption. [Price of each of the three publications, 2*s.* net, or 2*s.* 3*d.* including postage.]

BOOKS RECEIVED.

Plastics in Industry. By "PLASTES." London: Chapman and Hall, Limited. [Price 12*s.* 6*d.* net.]

Western Australia. Annual Report of the Inspection of Machinery Branch, Mines Department, for the Year 1939. Perth: Offices of the Mines Department.

Air Ministry. Meteorological Office, London. Southport Auxiliary Observatory (The Fernley Observatory of the Corporation of Southport). Annual Report and Results of Meteorological Observations, for the Year 1939. By G. A. LIDSTER. Southport: The Fernley Observatory. London: The Meteorological Office, Air Ministry, Kingsway, W.C.2.

Aircraft Identification. Friend or Foe? Part One (Revised). *British and German Fighters and Bombers.* [Price 2*s.* net.] Part Two (Revised). *British and German Troop Carriers and Seaplanes. British Trainers.* [Price 2*s.* net.] London: Temple Press, Limited, Bowling Green-lane, E.C.1.

Construction Planning and Plant. By A. J. ACKERMAN and C. H. LOCHER. London: McGraw-Hill Publishing Company, Limited. [Price 28*s.*]

Civil Engineering Handbook. Second edition. Editor-in-Chief: PROFESSOR L. C. URQUHART. London: McGraw-Hill Publishing Company, Limited. [Price 35*s.*]

Practical Mechanics and Strength of Materials. Third edition. By PROFESSORS C. W. LEIGH and J. F. MANGOLD. London: McGraw-Hill Publishing Company, Limited. [Price 21*s.*]

PERSONAL.

MR. LEONARD BROWN, general manager of the rubber manufactured-goods division of the Dunlop Rubber Company, Limited, Cambridge-street, Manchester, 1, has retired for reasons of health.

Messrs. Vickers-Armstrongs Limited, Vickers House, Broadway, London, S.W.1, announce that MR. R. P. H. YAPP, MR. A. B. GINGELL and MR. W. H. BUTLER have been appointed works commercial managers.

MR. F. W. BAIN has been appointed Chairman of the Chemical Control Board, Raw Materials Department, Ministry of Supply.

MR. F. G. ATHERTON has been made head of the Mining Department of the Francois Cementation Company, Limited, Bentley Works, Doncaster.

MR. R. HUNTER, chief engineer of the Burnt Island Works of the British Aluminium Company, Limited, has retired.

MR. H. R. MACMILLAN, Timber Controller for Canada, Dominion Department of Munitions and Supply, has been appointed Chairman of the War-Time Requirement Board, set up by a Federal Order-in-Council to ensure that war needs, in order of importance, take priority over all other requirements.

BRIGADIER-GENERAL C. H. MITCHELL, C.B., C.M.G., D.S.O., who has been Dean of the Faculty of Applied Science and Engineering, University of Toronto, since July, 1919, is retiring at the end of the present academic year.

THE BRITISH EMPIRE CHAMBER OF COMMERCE IN THE UNITED STATES OF AMERICA has removed its offices from No. 620 to No. 587, Fifth-avenue, New York.

MESSRS. ENSIGN LAMPS, LIMITED, have transferred their London depot to 98-100, Blackfriars-road, S.E.1. Commencing on Monday, February 3, full trade and service facilities will be available. The telephone number of the depot remains as heretofore, namely, WATerloo 4374-5.

TENDERS.

WE have received from the Department of Overseas Trade, Millbank, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained at the above address, quoting the reference numbers given.

Transformers, one 150 kVA, one 200 kVA and one 250 kVA, 6,600/380/220-volt, three-phase, 50-cycle, indoor-type, oil-immersed, with high-tension and low-tension switchgear, for the Mental Hospital, Krugersdorp. Union Tender and Supplies Board, Pretoria; March 13. (T. 15,287/41.)

Switchgear, extra high-tension, required in connection with a proposed mains extension. City Council of Pretoria; March 17. (T. 15,273/41.)

CUBAN LOW-GRADE MANGANESE ORES.—A description is given in a recently-issued technical publication of the American Institute of Mining and Metallurgical Engineers of the steps taken to concentrate a low-grade Cuban manganese ore. The author, Mr. F. S. Norcross, states that the ore, which contains about 17 per cent. of Mn, is treated by crushing, jigging and flotation methods. The concentrates, containing 44 per cent. of Mn, are finally nodulised by passing them through an oil-fired rotary kiln 213 ft. in length. The product is porous and granular, and yields, on analysis: manganese, 51 per cent.; silica, 8-11 per cent.; iron, 3-4 per cent.; alumina, 3-4 per cent.; and lime, 7-8 per cent.

THE LATE MR. G. E. GITTINS.—It is with regret that we record the death of Mr. G. E. Gittins, B.Sc. (Lond.), M.I.E.E., which took place on January 16. Mr. Gittins, who was sales manager of the Transformer Department of Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17, was born at Tunstall, Staffordshire, in 1871. He received his early training at the Wedgwood Institute, Hanley, afterwards proceeding to Chester College. He was lecturer in electrical engineering at Blackburn Technical College from 1899 to 1903, when he became head of the electrical engineering department of the Harris Institute, Preston. Mr. Gittins continued in this capacity until 1917, when he joined the British Westinghouse Electrical and Manufacturing Company (now Messrs. Metropolitan-Vickers Electrical Company), taking up a position in the switchgear engineering department, and, at the same time, lecturing at the Manchester College of Technology. In 1923, he was appointed sales manager of the transformer department, which position he was holding at the time of his death. Mr. Gittins was an active member of the Association of Mining Electrical Engineers and was President of the North-Western Branch in 1927-28. Until recently he was convener of the Examination Committee of the Association.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Inquiries at firms specialising in export trade show that more orders are circulating and prospects are brighter than has been the case for some time. The latest inquiries include: From Canada for drills, taps and dies, pliers, precision tools, vices, etc.; from South America for farm and garden tools; and from Egypt for railway rolling stock. Another promising feature is the increasing number of merchants abroad who wish to set up agencies for Sheffield-made goods. Among the countries concerned are Spain, Portugal, Switzerland, Canada, Australia, Iceland, and all the South American countries; the latter markets are interested in tools, general hardware, and tin-plate. The raw and semi-finished steel branches continue to make satisfactory progress. Basic steel and acid materials are in strong demand, and there is a run on steelmaking alloys and all grades of scrap. Melting furnaces are operating at full capacity, and some concerns are hoping to bring new furnaces into operation during the next few weeks. Rolling mills, forges, press shops, and slab and billet mills are all accounting for larger outputs. Wire and rod mills are active, and there is a better tone in the market for plates, sections, joists, angles and similar products. Cold- and hot-rolled strip are in strong demand. The heavy machinery branches are handling more Government orders, and the turnover in ordinary commercial business is also substantial. Crushers of all types and for all purposes are in demand, and a steady run has developed in colliery and mining requisites, tramway and railway trackwork, and dredger components. One Sheffield firm has just produced a table and base made of toughened cast steel for a 2,500-ton straightening press. Sheffield-made high-efficiency steels are in strong demand for the production of all types of electrical equipment, including generator sets, converting equipment, rolling-mill motors, transformers, switchgear, and roll heaters. Textile machinery is also an active line, and more business has come to hand for quarrying equipment. The medium branches are actively employed, and the tool-making trades are operating at full capacity.

South Yorkshire Coal Trade.—The export position shows little change, business being of a restricted character. The inland demand for industrial coal has been well maintained. Steams are a progressive line, and locomotive coal is being disposed of in larger tonnages. The house coal market has become more active, and merchants are beginning to reduce their heavy stocks. Foundry and furnace coke are steady.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—A change in the conditions governing the exportation of coal to Eire has just been announced by the Coal Export Officer, Cardiff, and will bring the Irish trade into line with other export destinations. Since the outbreak of war, shipments of coal, coke, and manufactured fuel to Eire have been free from the export control. This freedom has now been removed, and, in future, it will be necessary for shippers to produce coal export certificates at the Customs. Certificates will not, however, be required in respect of shipments to Northern Ireland unless the whole or a part of the shipment is intended for Eire. It has also been decided that, until further notice, the export to Eire of coals other than those produced in South Wales, Scotland, and, with certain exceptions, Durham and Northumberland, will not be permitted. An appointment recently announced in South Wales is that of Mr. Evan Williams, J.P., the present compensation secretary, to be general secretary of the South Wales Miners' Federation. He will succeed Mr. Oliver Harris. Mr. Williams has been connected with the Federation for 30 years. Foreign inquiry failed to show any material improvement in the market although a moderate trade was still passing for South America and Portugal. The demand from home industrial users was brisk, but with supplies of the high-volatile sorts, particularly sized and small classes scarce, little new business could be accepted for early delivery, and the tone was consequently very firm. Dry steams were still neglected and dull.

The Iron and Steel Trade.—Activities were well maintained in the iron and steel and allied trades of South Wales and Monmouthshire last week. The demand was sustained, but new business was restricted by the fact that producers were already heavily engaged.

THE SOCIETY OF ENGINEERS.—A branch of the Society of Engineers has been formed in Australia. The Chairman is Professor Sir Henry Barraclough, K.B.E., M.Inst.C.E., and the honorary secretary Mr. A. S. Lindsay, P.O. Box 2998 NN., G.P.O., Sydney, New South Wales, Australia.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Nearly all the iron and steel plants in this district are operating at full capacity. The heavy make, as well as the imports from America, are passing promptly into use and although the supply position has improved, adherence to the control of distribution regulations is still necessary. Rationing of tonnage for the usual commercial undertakings is on a somewhat improved scale, but still fails to satisfy all the customers.

Cleveland Iron Trade.—Foundry-iron consumers are making extensive use of scrap but require more pig iron. The output of the local blast furnaces is still intermittent, but supplies of foundry pig obtainable from other producing centres are ample for current needs. Midland brands are reaching North East Coast foundries in satisfactory quantities for ordinary purposes and adequate parcels of iron for particular purposes are coming to hand from Scotland and elsewhere. Merchants are able to transact a little more business than of late, but the tonnage at their command is below their requirements. The stabilised prices of Cleveland pig are ruled by No. 3 description at 128*s.*, delivered in the Middlesbrough district.

Hematite.—Hematite is in large and increasing demand. The control have supplies of American products at their disposal but these are distributed only among consumers who are unable to make satisfactory use of other iron. The situation will, however, be improved by the arrival of further tonnage from the United States. Second hands are managing to secure parcels that enable them to cover the actual needs of regular customers. The official quotations for both American and local hematite remain at the level of No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England buyers.

Basic Iron.—The nominal fixed figure for basic iron remains at 120*s.* 6*d.* There is none for sale, but makers have small stocks and are anxious to increase the tonnage stored. The requirements of their own consuming works are likely to increase still further.

Foreign Ore.—Foreign-ore consumers have moderate stocks and cargoes are arriving more regularly. The increasing use of ironstone from local and other home mines has, however, reduced the need for imported ore.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is light. The supply is plentiful but holders have extensive contracts to execute and are not pressing sales; local users have little occasion to buy. The fixed values for good medium qualities are 35*s.* 6*d.* f.o.r

Manufactured Iron and Steel.—The supply of semi-finished iron and steel is sufficient to keep the re-rolling plants fully employed. Manufactured-iron firms are turning out a heavy tonnage and bar producers have as much work as they can handle. Railway material is in considerable request, the demand for shipbuilding requisites is unabated and buyers of all kinds of sheets are pressing for larger supplies. Soft steel billets are quoted at 12*l.* 5*s.* per ton; hard billets at 13*l.* 12*s.* 6*d.* per ton; joists and sections at 15*l.* 8*s.* per ton; heavy plates at 16*l.* 3*s.* per ton; and heavy rails at 14*l.* 10*s.* 6*d.* per ton.

Scrap.—There are substantial stocks of iron and steel scrap, but contract deliveries are readily accepted and buyers are seeking to place extensive forward orders.

HANDBOOK FOR SHEET-METAL WORKING INDUSTRY.—Messrs. Lee and Crabtree, Limited, Shipley, Yorks, have published a second edition of their *Lecra Hand Book*. This, which is of handy pocket size, contains information on bending, blanking and drawing pressures; presses and press tools; press-work lubricants; drawing dies and other subjects of interest to those engaged in the sheet-metal working industry. Tables of metal gauges, dimensions of tin-plate sheets, decimal equivalents, strength and weight of materials, and other data are also included. The hand book, which contains 52 pages, has been compiled by Mr. J. Langton, B.Sc., M.I.Mech.E., manager of Messrs. Lee and Crabtree, and is obtainable, price 2*s.* 6*d.*, from the firm.

THE LATE MR. C. BERTRAM.—We note with regret the death, on January 19, of Mr. C. Bertram, A.M.I.E.E., who retired on April 30, 1939, after completing nearly 31 years in the service of Messrs. W. T. Henley's Telegraph Works Company, Limited, Milton Court, Westcott, Dorking, Surrey. Prior to joining the Company in 1908 as branch manager at Newcastle-upon-Tyne, Mr. Bertram had served an apprenticeship with Messrs. Clarke, Chapman and Company, Limited, and at the Heaton Works of Messrs. C. A. Parsons and Company, Limited. After serving for a time on the staff of the Newcastle District Electric Lighting Company, Limited, he entered the service of Messrs. D. Selby Bigge and Company. During his service with the latter company he carried out what has been described as the first electric-power installation in the collieries of the County of Durham.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

ROYAL SOCIETY OF ARTS.—Friday, January 31, 1.45 p.m., John Adam-street, Adelphi, W.C.2. "Recent Labour Legislation in India," by Sir Frank Noyce. Monday, February 3, 1.45 p.m. Cantor Lecture III. "The Influence of Art on Instruments of War," by Mr. J. G. Mann. Wednesday, February 5, 1.45 p.m. "Design and the Manufacturer," by Mr. E. W. Goodale.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 31, 6 p.m., The Mining Institute, Newcastle-upon-Tyne "Effect of Some External Factors on the Performance of Single-Screw Ships," by Mr. A. Kari.

INSTITUTE OF PETROLEUM.—Wednesday, February 5, 2.15 p.m., The Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Extreme Pressure Addition Agents," by Messrs. E. A. Evans and J. S. Elliott.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The consumption of steel material of practically all kinds continues to be exceptionally heavy. The shipyards are all securing a very large tonnage of plates and so also are boilermakers. There is also a heavy demand for sectional material for structural purposes. Makers of black and galvanised sheets are exceptionally busy at the moment and have sufficient orders on hand to keep their plant running at full capacity for months ahead. The supply of raw material is very good and local production is being supplemented by deliveries from overseas and from the south. Prices are steady and are as follows:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—A steady business is passing in the malleable-iron trade of the West of Scotland and makers are well provided with orders. The demand for re-rolled steel bars is still very strong and all plant is being operated at full capacity. Ample supplies of semies have been coming to hand recently and the outlook in this direction is quite satisfactory. The following are the current quotations:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There has been no change in the state of the Scottish pig-iron trade since our last report and output is being maintained at full capacity. The demand for both hematite and basic iron is very strong and the full output is quickly taken up. The arrangements made regarding supplies of raw materials have proved quite satisfactory. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

EGYPTIAN COTTON.—It has been decided that United Kingdom requirements of Egyptian cotton shall, in future, be purchased from the Buying Commission in Egypt by the Ministry of Supply. The detailed arrangements will be conducted by the Cotton Control. The Control will consider applications for import licences in respect of existing contracts for the purchase of Egyptian cotton which has not yet been shipped.

THE LATE MR. T. U. HILL.—We regret to have to record the death of Mr. T. U. Hill, which took place recently at his home, Hosie House, Hosie Croft, Westerham, Kent. Until his retirement in 1935, Mr. Hill occupied the position of London manager of The Carborundum Company, Limited, Trafford Park, Manchester, 17. He joined the Company in 1907 and took a leading part in the rapid growth of the abrasive industry in this country.

THE UNITED STATES STEEL INDUSTRY.—According to statistics issued by the American Iron and Steel Institute, the production of open-hearth and Bessemer steel in the United States during the first eleven months of 1940 totalled 58,946,185 net tons. The preliminary figure for the whole of the year is placed at about 65,250,000 net tons. This total, it is pointed out, does not include the output of steel made in the electric furnace, which may exceed 2 million tons.

WHEELER DAM AND POWER PLANT, TENNESSEE RIVER.

(*For Description, see page* 81.)

FIG. 39. TURBINE WHEEL BEING LOWERED INTO CASING.

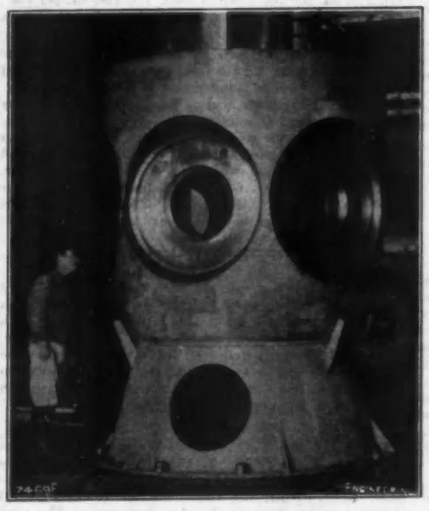


FIG. 40. HUB OF TURBINE WHEEL.

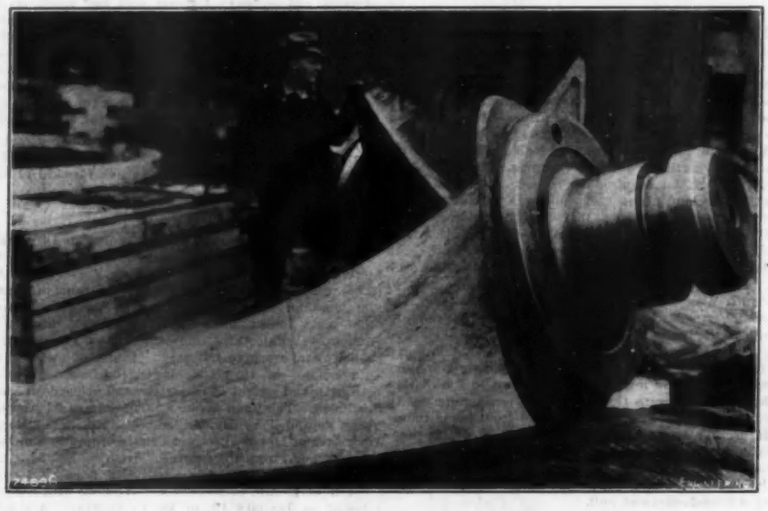


FIG. 41. BLADE OF TURBINE WHEEL.

LICENCE FOR TEMPORARY SUPPLY OF REFRIGERATING MACHINERY.—It is stated in *The Board of Trade Journal* that a licence has been issued whereby British Automatic Refrigerators (1936), Limited, may supply service equipment to any person carrying on a business in which refrigerating machinery or plant is used, during such time as refrigerating machinery or plant belonging to that person is being repaired, reconditioned or replaced. Accordingly, individual licences for the above company to supply such equipment in these circumstances will not be required.

NATIONAL CERTIFICATES AND DIPLOMAS IN ELECTRICAL ENGINEERING.—The secretary of the Institution of Electrical Engineers informs us that 1,275 National Certificates and Diplomas in electrical engineering were awarded in England and Wales during 1940. Of these, 843 were Ordinary Certificates; 370, Higher Certificates; 25, Higher Certificates endorsed; 33, Diplomas; and four, Higher Diplomas. Of the 48 National Certificates and Diplomas awarded in Scotland, 29 were Ordinary Certificates; 14, Higher Certificates; one, a Higher Certificate endorsed; and four, Higher Diplomas.

ANALYSIS OF FREE-CUTTING ALUMINIUM ALLOY.—The British Aluminium Company, Limited, Oakley Manor, Belle Vue, Shrewsbury, Shropshire, have issued a leaflet on which are tabulated recommended methods of analysis for the determination of silicon, copper, antimony, iron, zinc and other elements in free-cutting aluminium alloy B.A. 35. Copies of the slip, which constitutes an addendum to the volume *Chemical Analysis of Aluminium and its Alloys*, published by the company in 1938, may be obtained on application to the above address.

THE WHEELER DAM AND POWE PLA

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Fig. 30.

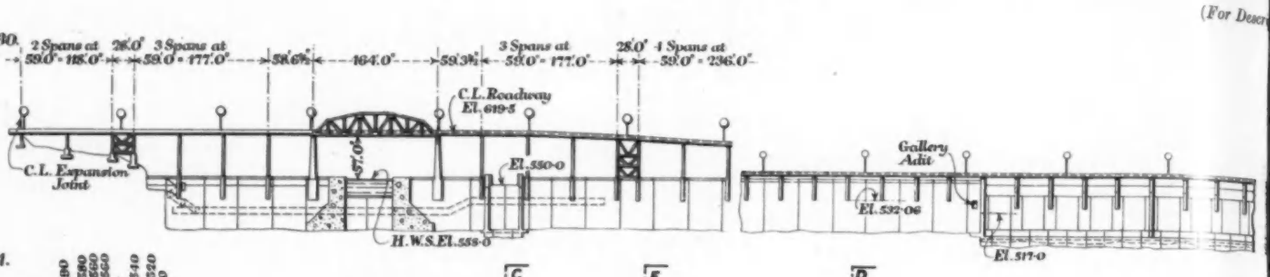


Fig. 31.

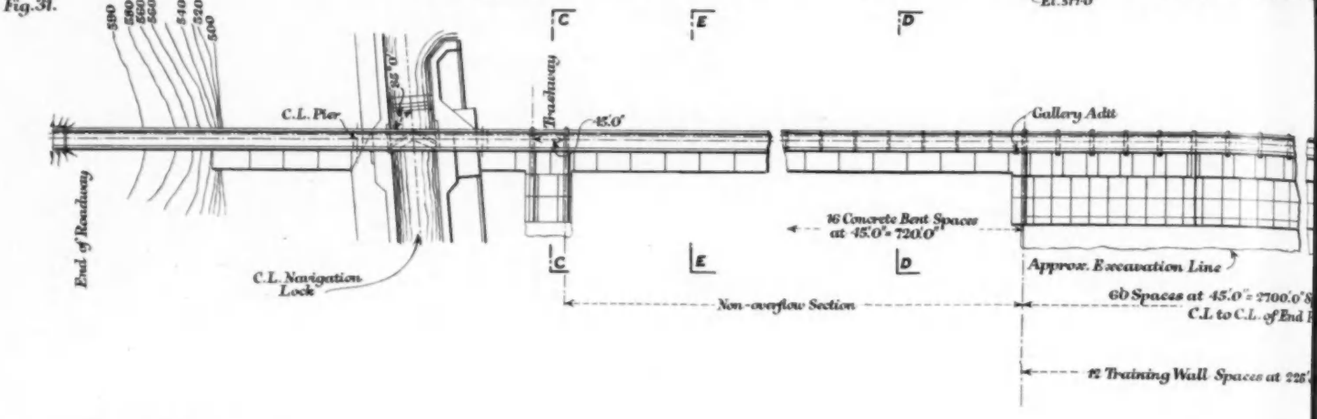
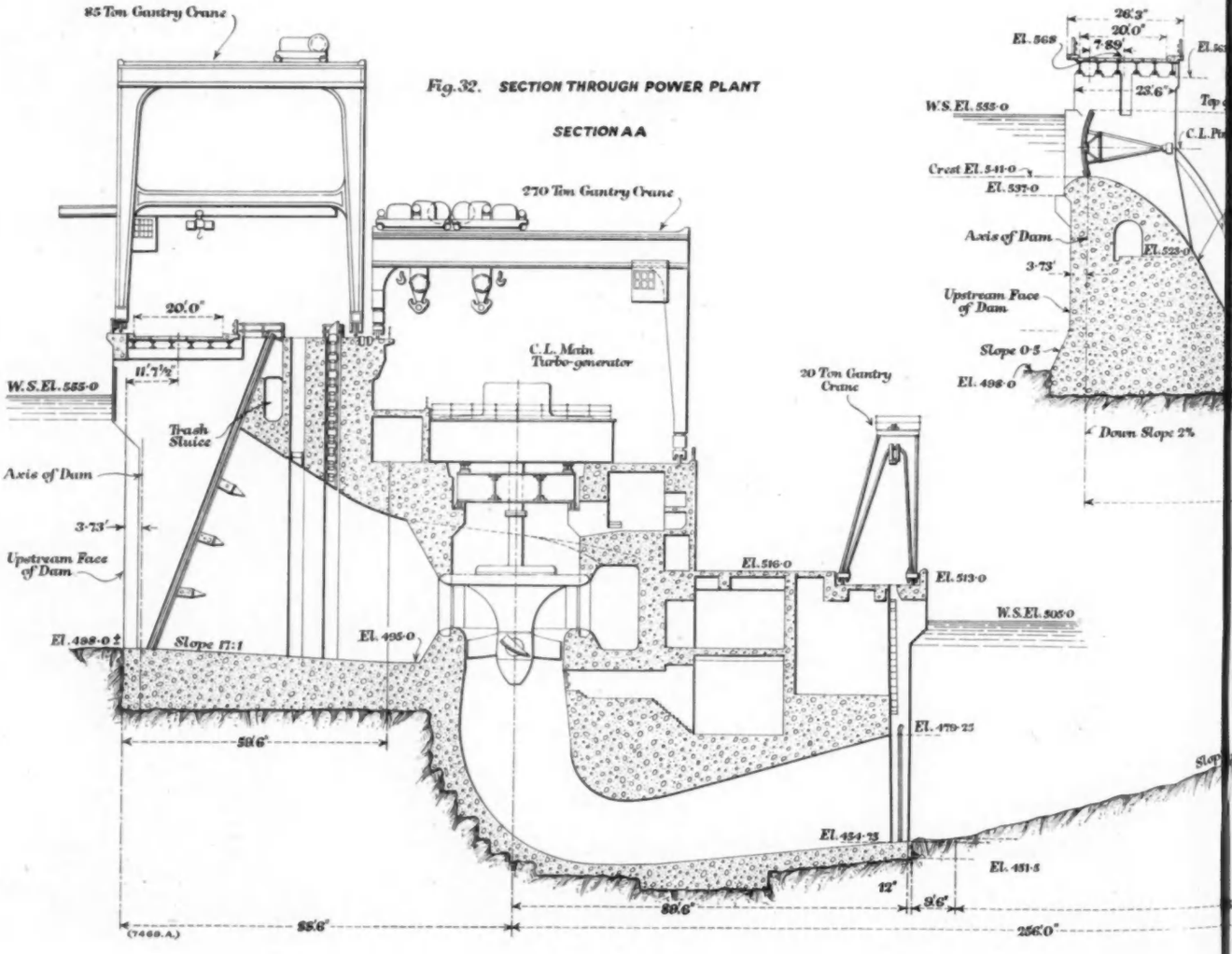


Fig. 32. SECTION THROUGH POWER PLANT

SECTION A A



OWER PLANT, TENNESSEE RIVER, U.S.A.

(For Description see page 81.)

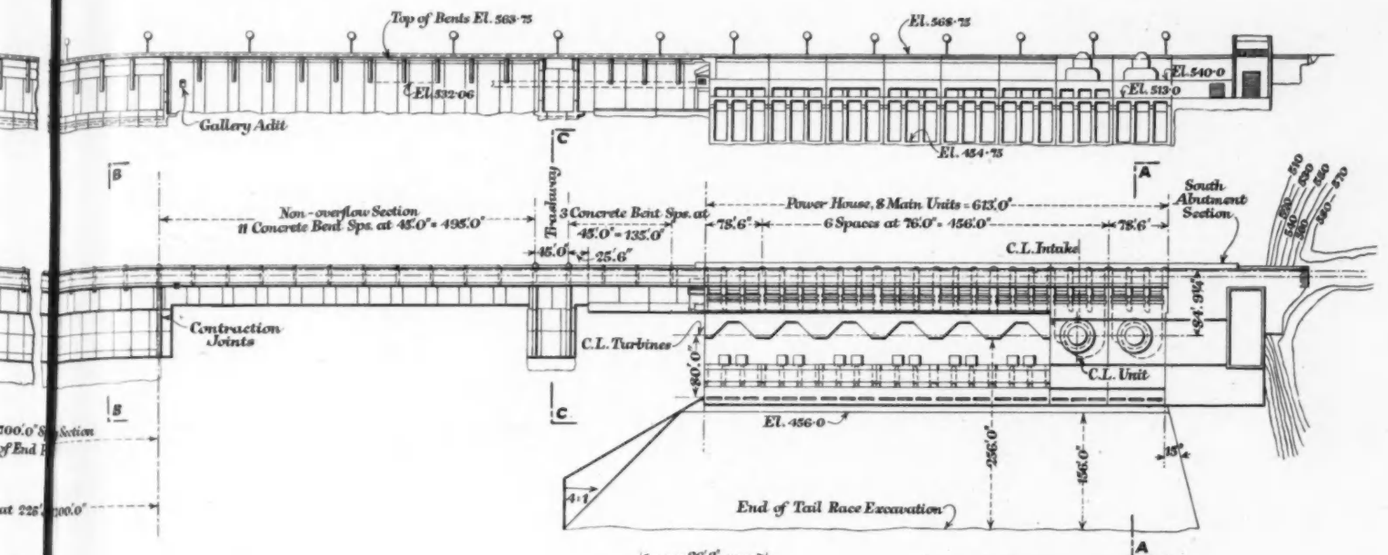
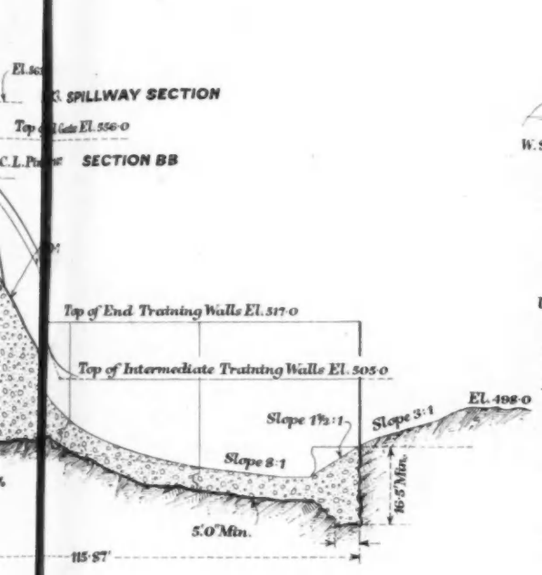


Fig. 34. TRASHWAY SECTION



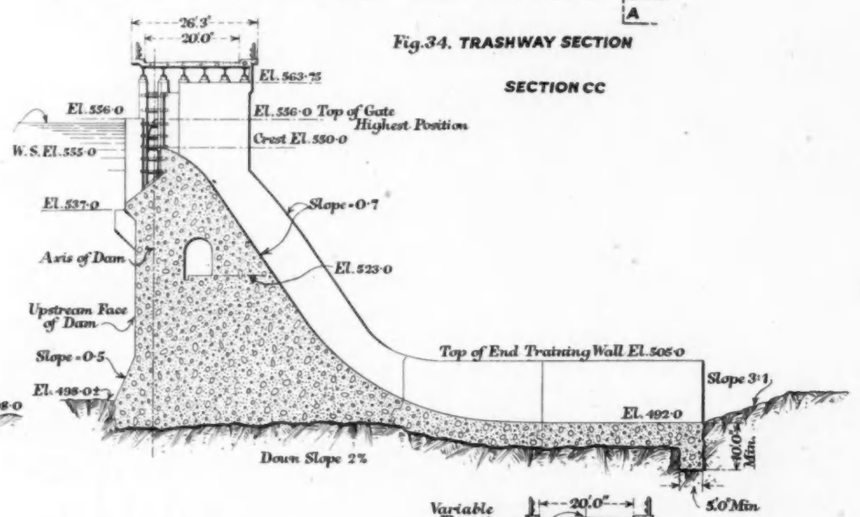
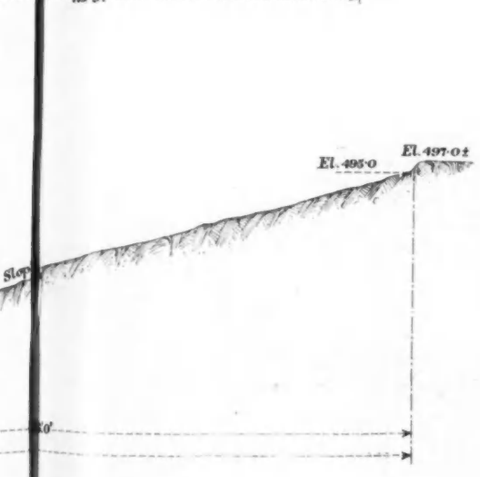


Fig. 35. SECTION DD



NON-OVERFLOW SECTIONS

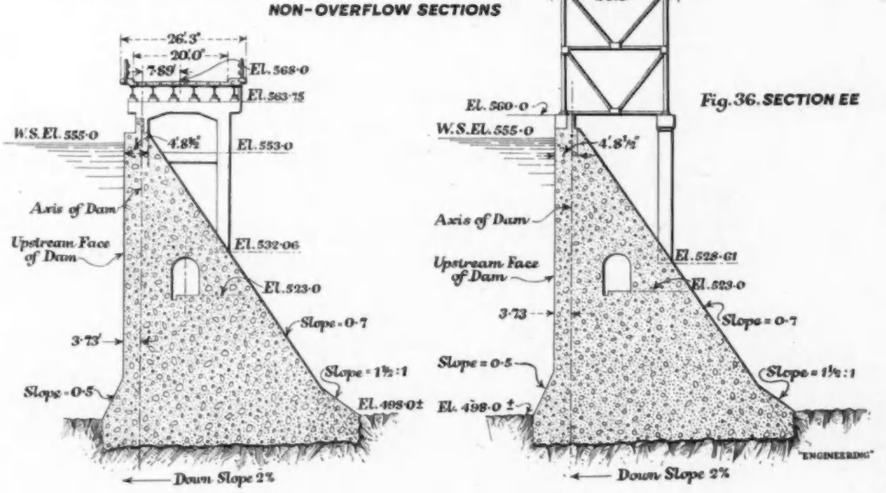


Fig. 36. SECTION EE

UNIV. OF MICH.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and other publications bearing somewhat similar titles.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

All accounts are payable to "ENGINEERING," Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2

TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

INDEX TO VOL. 150.

The Index to Vol. 150 of ENGINEERING (July-December, 1940) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, no copies of the Index are being distributed, except in response to such applications.

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ENGINEERING

FRIDAY, JANUARY 31, 1941.

VOL. 151. No. 3916.

DIRECTION AND PRODUCTION.

Two topics of widely dissimilar character, which, nevertheless, involve some matters of principle and policy which are closely allied, have engaged a considerable amount of attention in Parliament and Press during the past fortnight. With the outward and obvious causes for dissension in what may be termed the Old School Tie Controversy, aroused by Lieut.-Colonel Bingham's letter to *The Times* on the subject of cadet officers, this journal has nothing to do and little to say; except to observe that the basic idea that Army promotion should normally be from the ranks as an essential part of the "democratisation" introduced by Mr. Hore-Belisha, during his tenure of the office of Secretary of State for War, merely copies what has been the normal process of training for technical executive appointments in engineering works for many years. To a less but still a notable extent, this now applies to many other forms of commercial undertaking. If Dr. Johnson professed to scorn the principle that "Who rules o'er freemen should himself be free," declaring it equally reasonable to maintain that "who drives fat oxen should himself be fat," it ought to be remembered, before impressing him into the opposition, that a riposte directed by no higher motive than to make a dialectical point should not be quoted without its context. In any case, there can be no question that "who rules o'er skilled men should himself be skilled"; and while heredity may influence aptitude to learn, there is no true substitute for practical experience.

The other outstanding topic, and one which is of more direct concern to the engineering industry, is the speech by the Minister of Labour and National Service in the House of Commons, on January 21, wherein he outlined the Government's plans for the mobilisation of industrial resources and of the nation's man- and woman-power, for the expansion of war production. Mr. Ernest Bevin was at pains to explain that he was speaking not only for the Ministry of Labour, but for the Government, and that he had committed his speech to writing "so that accuracy might be assured"; an authentication which adds some interest to the proposals, though without making any clearer the grounds on which some of them are based, or the reasons for supposing that they will attain the desired ends any more efficiently and expeditiously than the methods previously in use. That the House was in thorough accord with the primary purpose of the proposals was evident in the subsequent debate, but it was notable that, although the present House contains many Members possessing first-hand industrial experience, at no time did the debate turn upon the practical aspects of the far-reaching innovations.

The nature of these innovations has been widely publicised in the daily Press, but those which directly affect the conduct of engineering industry may be briefly reviewed. In order that "the whole business of production and supply should be gripped and controlled at the top by a small and compact directing body," there is to be a Production Executive, consisting of the Ministers of the four principal producing Departments, together with the Minister of Labour. An Import Executive, consisting of the five Ministers responsible for the main importing Departments, will have at its service the "handling Departments," concerned with shipping, transport, merchant shipbuilding and repairs. The Prime Minister retains the responsibility of ensuring that these Executives carry out the policy of the War Cabinet.

The arrangements proposed for the improvements in the use of man-power in cargo-handling, shipbuilding and repair, building construction and repair, agriculture, and essential exporting trades, while they aimed at the betterment of working conditions by the provision of canteens, hostels, improved lighting, etc., were couched in general terms which left many obvious questions unanswered; more especially, how the requirements of the Services were to be reconciled with the additional demand for skilled men which must accompany any further expansion of production. Some indication was given, however, of the steps to be taken to avoid the use of skilled men on work not requiring particular skill, in the Army and Royal Air Force and in industry; and Mr. Bevin stated, also, that the Admiralty and the Ministry of Aircraft Production were being asked to expedite their training efforts. So far as the normal reserves of manual labour were concerned, however, the Minister continued, "the reservoir was practically dry" and new steps must be taken to draw upon the personnel of non-essential trades and to recruit more women for work of national importance. Even so, new methods must be adopted to provide the labour necessary to staff the new national factories now being completed.

To quote Mr. Bevin's words, as reported in the official report: "In the case of people employed in offices and on managerial and supervision work of all sorts, firms will have to make a careful survey and see, by a rearrangement of duties, how many men can be placed on productive work instead of office work. We shall ask people engaged in all kinds of occupations, whether on directorates, businesses or professions, or elsewhere, to come forward and play their part . . . It will be necessary to have industrial registration by age-groups and by this means to make a list of those who should be called upon to serve the State in national industry. . . . In certain types of vital war work . . . the right of dismissal must be taken out of the hands of the employer, except for misconduct. . . . The question of personnel management will have to be brought under control and where we are satisfied that the arrangements for proper labour management or workshop consultation do not exist, a personnel controller must be appointed . . . and on him will rest responsibility for engagements and terminations of employment, and all other matters touching the welfare of the employé as may be determined. Production departments will have to replace any inefficient management. . . . The directions will only be used for service in the interest of the State and for the war effort."

The former Lord Chief Justice, Lord Hewart, once laid down a principle which, *mutatis mutandis*, is applicable to a field even wider than that of the Law. "It is not only necessary that justice should be done," he declared, "but that it should manifestly appear to be done." Similarly, it may be postulated as a basic principle of Government, especially in

time of war, that it is not merely necessary that the national interest should be served by such fundamental changes in industrial administration as are now proposed, but that it should manifestly appear to be served. In this respect, some of the proposals do not entirely satisfy the doubts which are aroused by suggestions to enforce a compulsory change of horses in the middle of the stream.

There have been many occasions in the past, however, and there may well be more, when organisations have been condemned for failure to work, but the real reason has been that they were given no opportunity to do so; and it may be questioned whether the Government are justified in assuming that the vital industries are going to fail in their responsibility to the country to such an extent that the managements must be virtually superseded at the outset. Later in his speech, Mr. Bevin commented on the criticism that the powers of compulsion granted by Parliament in May, 1940, had not been exercised. "I can assure the House," he said, "that unless this question is handled with very great care, we might easily do more harm than good, and hinder the war effort. Courage takes two forms. One is to know when to use powers, and the other is to know how to use powers." Ignoring the rhetorical inexactitude of the assertion that knowledge can be a form of courage, it might be suggested that there is a third variety of knowledge, sometimes of still greater importance and requiring a firmer courage in its application; and that is, to know when not to use or even to seek powers.

The vital industries of this country have been directed for many years by highly trained specialists. It appears to be the fashion in some quarters to assume that directors, as a class, are not actively engaged or practically skilled in the operations of the businesses that they direct, but are merely financiers, concerned only to juggle with market values. This is a dangerous doctrine if it is to be used as an excuse to replace them by Government officials whose main functions, apparently, are to be "workshop consultation . . . and all other matters touching the welfare of the employé as may be determined." There will be no objection to the general principle that inefficient managements should be replaced, but it is very necessary to ensure that they should be replaced by some more efficient management, and the sole basis for judging efficiency should be that of output; and, before the fiat goes forth, it should be clear "beyond a peradventure" that the inefficiency is inherent in the management and not the result of interference from without. It is here that the parallelism appears between the Old School Tie Controversy and the proposals for the reorganisation of industry. The ability to direct is partly a product of heredity, partly of training and partly of environment and example. That a large proportion of public-school boys should eventually become directors (using the term in its widest sense) is probably less due to the fact that the boys attended public schools than to the fact that their parents, in very many cases, have worked their way to the top, often from very modest beginnings, and are in a position, not only to spend the extra money on their sons' education, but to inculcate by example the qualities of an efficient director. Thus there develops, in course of time, a social stratum of actual and potential directors, whose opportunities are undoubtedly wider than those of their less fortunate fellows, but who are, in the main, much better equipped to make use of them. This stratum is by no means static as regards its component personnel, but is changing perpetually as some drop out and others, from all levels of the nation, come in to take their place. To suppose that their places can be effectively filled at a moment's notice by relative amateurs, even when backed by compulsory powers, is to expect rather too much of the law of averages. Transferring office staffs to the shops may relieve the strain somewhat, and there is little doubt that the transfer of a large proportion of the temporary officials of some Government departments would relieve it still more; but it is difficult to see how efficiency in production is to be promoted if the employer who knows his job and the capabilities of his employees, is to be refused the right to promote the good men or discharge the incompetent.

THE THOMAS LOWE GRAY LECTURE.

THE subject which Dr. S. F. Dorey selected for the 13th Thomas Lowe Gray Lecture, presented on Friday, January 24, before the Institution of Mechanical Engineers, was "Progress in Marine Engineering as Influenced by the Classification of Ships"; an apt choice in view of the origin of this series of annual lectures, which was founded by means of a bequest made by Thomas Lowe Gray, in commemoration of his father, Thomas Gray, a former official of the Mercantile Marine Department of the Board of Trade. The prime function of this Department is to ensure the safety of ships at sea, and it was Thomas Gray, we believe, who composed the familiar rhyming version of the "Rules of the Road at Sea"—"Green to green and red to red, Perfect safety—Go ahead," etc.—which every deck apprentice or cadet learns as one of the fundamentals of his adopted calling. There has not always been so close a liaison between the Board of Trade and the various ship-classification societies as exists to-day; indeed, there have been many occasions in the past when that Department has been accused of excessive preoccupation with the letter of their terms of reference, to the neglect of the spirit. The fact remains, however, that the growth of ship and machinery classification societies in this country, where they originated, has owed much to the existence of the Mercantile Marine Department; and, when Dr. Dorey prefaced his remarks on the development of Lloyd's Register of Shipping with the observation that his lecture, though necessarily confined to the work of that Society, in which he is Chief Engineer Surveyor, was intended as an example of that of marine classification societies in general, it may be assumed that he included in that category the office with which Thomas Gray was so intimately concerned.

The story of the Underwriters' Green Book of the mid-Eighteenth Century; the Shipowners' Register, or Red Book, first published in 1799; and the eventual amalgamation of these rival Registers in 1834 as Lloyd's Register of British and Foreign Shipping (subsequently amended in title by the omission of the redundant "British and Foreign") has been often told and need not be repeated here. It may be pointed out, however, that the original constitution of 1834 has remained virtually unaltered, and that the guiding principle throughout has been the cautious one of requiring that innovations in ship design, construction and propulsion must be proved by experience before they can be recognised and admitted as approved practice. The acceptance of this principle at an early stage is indicated by the fact that no steam vessel was "classed" until 1822, when the name of the steam packet James Watt appeared in the Green Book; and its continuance is sufficiently attested by the modern instance of the use of welding.

In some respects it may be considered that the "influence" of classification on marine engineering, indicated in the title of the lecture, has been rather one of retardation than encouragement; indeed, criticism of this kind has not been lacking from time to time, from shipowners and shipbuilders, and occasionally from entirely disinterested observers who felt, rightly or wrongly, that a seeming excess of caution was hampering British shipping in its competition with that of other nations. There are two effective answers to this argument, however; although, rather curiously, Dr. Dorey mentions the one only by implication and the other, apparently, not at all. The first is provided by the attitude of the shipowners themselves towards the classification societies, as attested by the graph showing the aggregate tonnage of classed vessels; in 1939, 9,497 ships, totalling 32,186,370 tons gross, were classed with Lloyd's Register alone. The second counter-argument is the fact that classification is entirely optional; no owner, in this country, at any rate, is under any legal obligation to seek the classification of his ships or to retain it. That so many owners should do so, when all that the law requires is compliance with the regulations of the Board of Trade, is due in part, of course, to the fact that marine insurance companies require the additional security represented by classification; but this is by no means the only explanation, even when reinforced by the preference of shippers, especially in foreign ports.

There can be no question that a major influence, accounting for the large proportion of the world's tonnage which is classed with the British non-compulsory societies is the high standard of the technical services afforded, and the integrity with which they are administered. The pace of marine engineering development has quickened enormously within the past 30 years, largely as a result of the previous war and the disastrous years of subsequent depression, which stimulated research, first, in the direction of improvements in power-weight ratio and then in the endeavour to achieve greater economy in operation. Technical advances on land have provided a further stimulus, and the combined effect has been to require a much more scientific outlook on the part of the designer, builder and operator of marine machinery of every kind. In very many directions, however, the advance has been so far extended that it is no longer practicable for any individual so engaged to keep abreast of all the latest developments or adequately to assess the effects of their mutual interactions. The problems involved in the use of welding, or the employment of many of the new high-duty materials now available, are cases in point. Welding is more than a mere alternative form of fastening; it introduces questions of design which are being solved only gradually, partly by the aid of *ad hoc* research, but largely also by the accumulation of comparative data, only to be acquired by experience and, consequently, after a passage of time. Many of the new materials, admirable in certain respects, possess limitations which, similarly, require time for their proper evaluation, and the consideration of factors, the importance, and even the existence, of which may not be appreciated by every intending user. In circumstances such as these, the value of a central organisation that is able to collect and collate masses of relevant data, much of which would never become available to individual firms can be and is immense.

This last-mentioned development is one of particular interest, in that it may easily presage a much wider application of the principles on which ship classification is founded and maintained. If the inspection services, and the certificates of quality, which Lloyd's Register places at the disposal of inquirers, can be extended for the benefit of owners and users of shore refrigeration plants, cold stores, and welded pressure vessels, and the manufacturers and users of steel, there appears to be no logical reason why the practice should not develop in directions not at present catered for, under the auspices of the same or similar organisations. In some degree, this already obtains in the case of plant of many kinds, for the regular inspection of which the various insurance companies, individually or jointly, maintain their own skilled staffs; but there is still room for considerable expansion—for example, in the case of road vehicles. We have even heard it suggested—in jest, it is true, but by no means in folly—that a "Lloyd's Register of Housing" would do more to maintain and improve the standard of modern house property, and to safeguard the purchaser against shoddy work and the occupier against incipient defects, than any amount of wordy legislation, often as ill-conceived as it is ill-received, both by those who have to apply it and by the ostensible beneficiaries. In the early days of ship classification, as Dr. Dorey recalled, the only basis for the assignment of a ship's character were her age and place of building; only with the advent of Lloyd's Register were her condition at the time of survey, and the state of her equipment, taken into account. Much of the insurance of buildings, at the present time, follows the former practice rather than the latter. Apart from the structural property of all kinds that will have to be rebuilt after the war, there will be a very great deal that will have to be revalued—and not merely re-assessed—in the light of its then condition and the revised standards of the day. The suggestion that there should be some independent, expert and disinterested society, to which recourse could be had in such circumstances, may seem fanciful, but it might be worth pondering.

NOTES.

ARMY MECHANISATION AND AIR RAID PROTECTION.

IN an address delivered before the Northern Ireland Association of the Institution of Civil Engineers, a synopsis of which is published in the January issue of the *Journal*, Mr. R. E. L. Clarke observed that modern fire power had rendered assault more difficult and had reduced the effectiveness of the bayonet. The British tank offensives in 1917-18 were revolutionary. The method of attack by "infiltration," which was expounded by the French infantry captain, André Laffarge, in 1915, was first employed by the German Army in March, 1918. Hitler had mechanised and speeded up the tactical system. The method of "elastic defence" or "defence in depth," which was a corollary to infiltration, was first used by the French north of Verdun and the Hindenberg and Siegfried lines were notable examples of it. The mechanisation and motorisation of the British Army had been urged by General Sir John Dill, by Major-General Fuller and by Major-General Wavell, and had been accepted in principle by the Government. The battle of the Ebro witnessed the first test of attack on a large scale by motorised infantry supported by tanks and aeroplanes. That technique was further developed in the German mechanised attack on Belgium and France. The answer to such an attack lay in the use of a similar or more developed technique supported by "defence in depth." More complete mechanisation, Mr. Clarke said, should produce equal fire-power with fewer men and thus release munition workers. Motorisation on a larger scale would relieve the heavily burdened infantryman and enable him to carry body arms to protect the vital organs. Battle training, according to Mr. Clarke, should be based upon the latest developments of attack and defence, and dominant superiority in the air was likely to be a decisive factor. Diminished vulnerability was very important, particularly in connection with air raids, which struck readily at vital sources of power. Dispersal was effective only when bombs were aimed at definite objectives. Civil and military engineering experience was very valuable in the planning of air-raid protection. Apart from the use of steel or armour plate, reinforced concrete had been found to give the greatest degree of all-round protection. Provided conditions were suitable, below-ground protection was best. Shock waves were damped by soft materials and a large bomb which would smash through 15 ft. of concrete would probably not penetrate two 5-ft. blocks of concrete with 5 ft. of earth between them. Of the official shelters, in the absence of demolition loads and flooding, the Anderson type, sunk about 4 ft. into the earth, provided the best protection. Basement shelters were generally the least satisfactory.

THE RIVER MURRAY BARRAGE.

The Adelaide correspondent of *The Times* gives some interesting details of the five barrages which have recently been constructed across the mouth of the River Murray by the South Australian Government in co-operation with the Murray River Commission. The object of the work is to ensure the freshness of the river and to allow water to be supplied to numerous reclamation areas. In this way it is hoped to remove a threat to the dairying and other primary industries on the banks. The total length of the barrages is nearly 25,000 ft. The most important section of the work was the Goolwa Barrage, which, although only 2,075 ft. long, accounted for nearly half the total expenditure of 750,000*l*. This is due to the depth of the water at the site, the result being that the barrage impounds about 70 ft. of the total flow. The foundations are in fine sand and silt, into which 4,770 timber piles with a maximum length of 40 ft. have been driven. The piles are surmounted by a concrete raft which, in turn, carries a series of concrete piers. These piers are formed with grooves to receive adjustable stop logs. The works include a lock chamber for passing fishing and pleasure boats, with a navigable pass for larger vessels. The largest barrage is at Tauwitchere Island and is 12,000 ft. long; the other three are 7,450 ft., 2,600 ft., and 800 ft. long, respectively. Roadways connect the barrages across two islands. The works have been constructed some distance from the sea, to minimise the risk of damage during the heavy storms which occur frequently along the coast. At the same time, they have been kept downstream of the line of any possible ship canal between Goolwa and Victor Harbour. The barrages, being in tidal waters, have to stand pressure from both sides and are designed to allow a flood to pass without raising the flood level in the lower river. Three of them are intended to regulate the level of Lake Alexandrina by stop logs in the sluice-way. The other two will be closed except during floods or periods of high river. The works are part of a general scheme which will fulfil a movement, initiated as long ago as 1857, to regulate and divert the waters of the River Murray and its tributaries for the development of the adjoining country and to permit permanent navigation of the river.

THE JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

About six months ago the Council of the Institution of Electrical Engineers pointed out that paper rationing, increased expenses and the feeling that the existing arrangements were not altogether satisfactory, rendered it advisable to modify the lay-out and alter the methods of distributing the *Journal*. The issue of the *Journal* for January, 1941, is the first to be published under the new arrangements. It contains a foreword by the President, Mr. J. R. Beard, in which he remarks that the principle having met with the general approval of the members it now remains to be seen whether this attitude will be maintained in practice. His own view is that the change of form, which is now an accomplished fact, has much greater justification than merely saving paper and preventing undue increase in the cost of publication. The reasons are that for some years past much of the material in the *Journal* has been of a highly specialised character and therefore of interest only to limited sections of the membership. By distributing the full proceedings to every member, individuals received a rather forbidding bulk of highly technical matter of which only a portion was of direct interest to them and even that was made difficult of approach by being cumbered with other matter. To overcome this drawback the *Journal* has now been divided into three parts. Part I will contain all matters likely to be of general interest to members. For instance, the current issue contains the presidential address and three addresses delivered by chairmen of the Meter and Instrument, Wireless and Transmission Sections, respectively. It will also contain abstracts of all papers and "Institution Notes." This part is to be issued monthly and all members will receive it free. On the other hand Parts II and III will include in full all specialised papers on "Power Engineering" and "Communication Engineering," respectively. Part II will be issued in alternate months and Part III quarterly, and for both a small additional charge will be made. Part III will also incorporate the "Proceedings of the Wireless Section." The new feature of giving abstracts of all papers in Part I will, it is felt, be of considerable interest to all members. These abstracts, it is understood, will be sufficiently complete to indicate the nature and scope of the papers and to enable members to decide whether any paper is of sufficient interest to them to justify reference to the full paper. They will also be designed to bring out the main principles for the benefit of those members who have no specialised knowledge of the particular subjects.

THE DEMOLITION OF THE NINTH AVENUE ELEVATED RAILWAY.

According to the *Engineering News Record*, between the time when operations were begun in October and the end of December the work of demolishing the 11-mile stretch of the New York Ninth-avenue Elevated Railway from the Battery to the 155th-street Station has proceeded rapidly. An average of 600 men was employed and the equipment used consisted of cranes, working both from rail and street level, and a large fleet of lorries. By the end of the year the stripping of the deck work had been completed and about two-thirds of the heavy structural steelwork, the total weight of which was 55,000 tons, had been removed. Since none of the steel was allowed to go out of the country, it was loaded on to barges for shipment to New Jersey, whence it was transported by rail to the Pennsylvania steel mills. The good timber was also salvaged. The procedure adopted in carrying out the work of demolition was as follows:—The rail fastenings were removed by hand tools and the rails were cut into convenient lengths by acetylene blow-pipes. The rails were then stacked on the structure and the emergency walks and hand rails removed. Cranes, mounted either on the structure or on trucks at street level, depending on the height above the street and the position of the supporting columns, were employed to lower the material on to lorries. On the completion of this part of the work the stringers near the supporting columns were cut with blow-pipes, a crane being employed to take the strain as two stringers with their cross-bracing were lowered into the street as a unit. The tops of the bents were also cut off and lowered, leaving only a short section of the columns standing. The base of each column was next excavated to the anchor bolts, which were burned off and the columns were then removed to clear the site. Finally, the openings in the roadway were filled and the excavation made good to the existing standard. The blow-pipes were supplied from a mobile unit, consisting of either a scaffold or a two-wheeled cart, which carried five cylinders of oxygen and one of acetylene. This was sufficient for a day's supply and the blow-pipes were so large that rapid burning was possible without prior removal of the rust or dirt being necessary. When lead-painted steel was cut the workers wore masks, which were supplied with air through a filter strapped on the back.

THE EMPIRE'S SEA EFFORT.

Speaking at a lunch-time meeting of the Royal Empire Society, in London, on January 21, Admiral of the Fleet Lord Chatfield referred to the great progress made by the Dominions in the building and equipping of naval vessels, and in the training of personnel. In the course of his address, which was entitled "Our Empire's Sea Effort," Lord Chatfield said that whereas, in 1939, the Royal Canadian Navy consisted of 13 ships, with a personnel, including reserves, of just over 3,000, it comprised 155 vessels, with a personnel of 13,000, in 1940. Moreover, a great deal of shipbuilding work was going on in the Dominion; thousands of men were working day and night in 15 shipyards on the coasts and inland waterways. Upwards of 100 vessels for Naval and Air Force purposes had been called for, including 64 patrol ships and 26 minesweepers, and many had been delivered last year, while others would be placed in commission this year. Before the war, the Royal Australian Navy comprised five cruisers, five destroyers, two escort vessels, and one surveying ship. The expansion which had since taken place had been referred to in a broadcast on Defence by Mr. Playford, the South Australian Premier. He had said that in the space of 14 months, there had been an increase of 250 per cent. in the numbers of officers and ratings, and that ten naval vessels had been laid down, including destroyers and patrol vessels; in a few months the output would reach two vessels a month. New Zealand had also played an important part. H.M.S. Achilles was a unit of the New Zealand Division and a number of trawlers and other vessels were doing minesweeping and anti-submarine work. The Royal Newfoundland Naval Reserve provided a body of splendid boatmen, who were in great demand when small boats had to be launched in rough seas. Shortly before the outbreak of war, South Africa had created a local seaward defence corps and three companies, respectively attached to the Cape, the Eastern Province, and the Natal Commands, had been established. In 1939, the personnel of the Royal Indian Navy had consisted of just over 1,500 officers and men, and in the same year the Royal Indian Naval Reserve and the Royal Indian Volunteer Reserve had been established. By April, 1940, these reserves had provided upwards of 200 officers and 1,250 ratings, and the expansion, both on he active list and in the reserves, had been maintained. The sloops and other units of the Royal Indian Navy were doing invaluable work.

THE INSTITUTION OF MECHANICAL ENGINEERS.

A SPECIAL meeting of the Institution of Mechanical Engineers was held on Friday, January 24, at Storey's Gate, St. James's Park, London, S.W.1, for the purpose of presenting the James Watt International Medal to Professor Dr. Aurel Stodola, of Zürich. The chair was occupied by the President of the Institution, Mr. Asa Binns, Wh.Ex., who was accompanied on the platform by His Excellency the Swiss Minister, Mr. Walter Thurnheer, by Mr. Ota Vojtisek, a representative of Czechoslovakia, and by Mr. C. G. Du Cane, who represented the Engineering Institute of Canada. Mr. Binns, in introducing these gentlemen to the meeting, said Sir Vincent Massey had also intended to be present but had been called away to the Colonial Office. Mr. Binns emphasised the international character of the award about to be made. Dr. Stodola was born in Czechoslovakia, and had been for long domiciled in Switzerland, and a Canadian professional society was one of those which suggested that he should receive the medal. It was awarded every two years and was the highest distinction that the Institution could bestow or a mechanical engineer receive. The James Watt Medal commemorated one who was not a scientist, but an inventor and producer, and it was rarely possible to find a recipient for it in whom these qualities were so rarely balanced as they were in James Watt himself. The Institution, therefore, was prepared to consider as possible recipients, men who had attained world-wide eminence in mechanical engineering in any direction —science and research, invention or production. Hence a great inventor, though he might not be a scientist; or a great thinker and teacher, designer, or great organiser of methods of production in engineering works, would be eligible. Professor Stodola had been nominated by the Swiss Society of Engineers and Architects, the Czechoslovak Society of Engineers and the Engineering Institute of Canada. Dr. H. L. Guy was particularly fitted to appreciate the research work done by Dr. Stodola and he would, therefore, call upon him to deliver the following appreciation of Dr. Stodola's work.

PROFESSOR AUREL STODOLA.

Professor Aurel Stodola—the senior Honorary Member of this Institution—was born in 1859 in a small Slovakian village in the shadow of the Tatra Mountains. A brilliant scholar from his earliest days, he graduated with highest distinction at the Polytechnikum in Zürich. His practical training was obtained in the workshops of the Hungarian State Railways, followed at Berlin and Paris by further practical work and studies in technical, physiological and economic subjects. After supervising the building of a leather belt factory for his father, he became a designer in the engineering department of Rustons of Prague, who introduced the Corliss engine to Austria and enjoyed a considerable reputation as builders of the steam engine. With eight years of such practical work as a preparation, Stodola was, in 1892, appointed Professor of Mechanical Engineering of the Swiss Polytechnikum at Zürich, where he remained with such advantage to the land of his adoption that the eminent position occupied in engineering by so small a country as Switzerland is due in no small measure to the skill and inspiration of his work and teaching.

Watt's vital improvement of the steam engine began with studies of the sources of loss in the engines of his day in the light of the scientific knowledge then available. Stodola, also endowed with great analytical ability and a capacity for sure and illuminating experiment, isolated and studied the losses and structural elements of steam turbines in the light of the accumulated knowledge of thermodynamics, of the flow of fluids and of heat, of elasticity and of stress analysis and constructed a scientific basis for steam turbine design which directly and materially aided its development and improvement. Watt gave the centrifugal governor to the steam engine. Stodola's earliest scientific work was concerned with the stability of governing by means of the servo motor, which, in steam turbine practice, was added to Watt's governor. If Watt, by inventing the indicator, enabled engineers to understand and measure what went on inside the cylinders of his engines, Stodola's investigations and researches enabled the designers of his day to picture, understand and calculate the operation of steam in the nozzles and blades which in the turbine replaced Watt's piston and cylinder. He demonstrated experimentally the fallacy of the belief that velocities of steam higher than that of sound were associated with prohibitive loss. He established the correct principles for the design of divergent nozzles and the moving blades which co-operate with them, and explored and explained the significance of steam shock. Watt experimented on latent heat and the properties of steam and discovered the importance of cylinder condensation. Stodola experimentally investigated Martin's suggestion that "under cooling" explains an anomaly of the expansion of steam in a turbine, and proved that, with commercial steam, condensation begins at expansion ratios much less than the Wilson line. Watt was the first to employ a slide rule in engineering calculations. Stodola employed many intricate mathematical processes in the solution of engineering problems, and was the first to apply the Lanchester-Prandtl theory to the flow of air in centrifugal compressors.

The strength of the slow-moving parts of Watt's engines was determined by the loads they transmitted. In the fast-moving parts of the steam turbine, such loads are small and the dimensions are controlled by stress arising from their own motion, or by their tendency to vibrate. In these new fields, Stodola, by his investigations and experiments on the critical speed of turbine shafts, of moving blades, and of loaded discs of practical form, and by his method of assessing stress in them, made straight the way of engineers engaged in developing turbines and high-speed machinery.

But Stodola's work was not confined to the steam turbine. He also followed and contributed to the development of the internal-combustion engine. At an early date he introduced the gas entropy chart and the device of the kilogram molecule in the solution of gas-cycle problems. He produced analytical solutions to many of the problems arising in the theory and development of the gas turbine and acted as consultant to Holzwarth in that field. Stodola's skill and integrity are such that the most eminent and competing manufacturers of many countries did not hesitate to seek his advice in their gravest and most intimate problems. Yet, who, knowing Stodola, will not find a similarity in the characteristic modesty and meticulous caution in stating results which caused Watt, when soliciting the help of Dr. Small, to write :—"Remember also, I have no great experience and am not enterprising, seldom chusing to attempt things that are both great and new. I am not a man of regularity in business and have bad health. Take care not to give any a better opinion of me than I deserve; it will hurt me in the end."

Watt set himself to learn German as a mental exercise, and so that he might read certain books of engineering interest. Stodola added English to Slovak, German and French, that he might enjoy intercourse with us, study our scientific and technical work and delight in the rich heritage of our literature. One pleasing memory is of an evening in a small hotel in Bohemia, with Stodola expounding the subtlety and wit of Samuel Butler to some score of engineers of a dozen different countries. Watt was tone deaf, for it is said that "he did not know one musical note from another," yet as a boy he made a model barrel organ, and, in later life, mastered the theory of music so that he might build pipe organs for Scottish churches. Stodola acquired considerable proficiency in playing such organs, and throughout his life found solace and refreshment in his beloved music. They are alike, too, in that the vast total of work covered in their long life is a triumph of intense mental activity over physical frailty.

In the name and memory of James Watt, we unite to do honour to Aurel Stodola, a great engineer, a great teacher, and a great gentleman.

The President then handed the medal to Mr. Thurnheer, who, in accepting it, said that the bestowal of the James Watt Medal on Professor Stodola conferred an honour upon Switzerland. Professor Stodola deeply regretted his inability to be present in person at the meeting, but had written thus :—"I wish to thank the Institution of Mechanical Engineers from the depth of my heart for the high honour it has chosen to bestow upon me. The liberal spirit which, at this time of world turmoil, is thus shown to me, moves me profoundly and deepens my reverence for the brilliant engineer whose name the medal bears. The combination of practical mind with inborn scientific ability and with, above all, genius, which are all fused in James Watt, will always remain an ideal for the engineer; he, indeed, must bear in mind that only a Divine hand could so combine in a memorable personality the glorious spiritual gifts which we admire and respect in James Watt, the 'Benefactor of Mankind,' the title by which we know him and which he deserves so well."

Mr. W. A. Stanier (vice-president) proposed a vote of thanks to His Excellency the Swiss Minister for his courtesy in receiving the medal on behalf of Dr. Stodola. Mr. Stanier alluded to the successful Summer meeting of the Institution at Zürich in 1911, and made appreciative reference to the Czechoslovak representative and to Mr. Du Cane. The vote was seconded by Lord Dudley G. Gordon, D.S.O.

The President then opened the ordinary monthly general meeting of the Institution.

The secretary announced that the following officers would retire by rotation :—President, Mr. Asa Binns, Wh.Ex.; vice-presidents, Dr. H. L. Guy, F.R.S., and Mr. W. A. Stanier; members of Council, Mr. O. V. S. Bulleid, Wing-Commander T. R. Cave-Browne-Cave, O.B.E., Mr. Christopher Hinton, M.A., Eng. Vice-Admiral Sir George Preece, K.C.B., Professor Andrew Robertson, D.Sc., F.R.S., Professor Dempster Smith, M.B.E., M.Sc.Tech., and Mr. C. H. Russell (associate member). The Council proposed the following names for the coming years, a greater number of nominations than there were vacancies being proposed, in accordance with the byelaws, in order to ensure a ballot. President: Mr. W. A. Stanier; vice-presidents: Dr. H. L. Guy and Professor A. Robertson. Members of Council: Mr. O. V. S. Bulleid, Wing-Commdr. T. R. Cave-Browne-Cave, Mr. C. Hinton, Eng. Vice-Admiral Sir George Preece, Professor Dempster Smith, Mr. Cedric B. Dicksee, Mr. Percy Jump, Mr. W. C. Mitchell, Maj.-General A. R. Valon, O.B.E., M.C., Mr. G. E. Windeler, and Mr. W. H. Evans (associate member). Mr. John H. Barker, of Warwick, was proposed as member of Council from the body of the hall and, the nomination having been duly seconded, the President announced that Mr. Barker's name would be added to the list.

THOMAS LOWE GRAY LECTURE.

The President then stated that the author of the 13th Thomas Lowe Gray Lecture, Dr. S. F. Dorey, Wh.Ex., was unfortunately unable to deliver it in person, but had sent a representative. The lecture was entitled "Progress in Marine Engineering as Influenced by the Classification of Ships," and was read by Mr. W. D. Heck, B.Sc., principal surveyor on Dr. Dorey's staff.

At the conclusion of the paper, a vote of thanks to Dr. Dorey and Mr. Heck was proposed by Major William Gregson, M.Sc. (member of Council), who commenced by reminding members that Dr. Dorey was Chief Engineer Surveyor to Lloyd's Register of Shipping, an organisation the name of which stood for honesty, excellency and integrity of purpose, and was recognised for such qualities in every corner of the world. It was, indeed, commonly believed that certain foreign shipping companies in the title of which the name "Lloyd" appeared had adopted that name as an adjective to enhance their own status. The slogan of Lloyd's was "Safety at Sea," but they did not allow their services in this direction to interfere with progress in marine engineering, helping this greatly by advice and research on technical problems.

The vote was seconded by Mr. E. Bruce Ball (past-president), who alluded to Dr. Dorey's membership of the Whitworth Society, to which the President of the Institution also belonged.

LETTERS TO THE EDITOR.

CHAIN-TRACK VEHICLES.

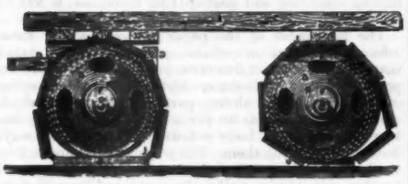
TO THE EDITOR OF ENGINEERING.

SIR,—In making a search through old engineering periodicals, for the preparation of some notes on the centenary of this firm, which was established in 1840, our chairman, Mr. J. S. Daniels, found an illustrated description, in *The Practical Mechanics' Journal* of January 1, 1860, of Matthew Leahy's invention of a track-laying vehicle. In view of the excellent performance that British tanks have been putting up in the Western Desert recently, readers of ENGINEERING might be interested in Leahy's invention, which would appear to be the predecessor of the modern tank, in that it describes the rudiments of the chain track.

Yours faithfully,
For T. H. and J. DANIELS, LIMITED,
J. L. DANIELS,
Director.

Lightpill Iron Works,
Stroud, Gloucestershire.
January 18, 1941.

[We have pleasure in publishing Messrs. Daniels' letter, to record their accession to the ranks of centenarian engineering firms; but would point out that there were various patents embodying chain



tracks, of earlier date than Matthew Leahy's, which were adopted by several British manufacturers of agricultural and military vehicles. Rhys Jenkins, in the introduction to his pamphlet, *Power Locomotion on the Highway* (1896), has the following note: "Boydell, in 1846, patented an improvement in wheel carriages by which each wheel was made to carry and lay down its own railway or track. Wheels of this description were fitted to gun carriages and used with success in the Crimea. In 1854, Boydell patented the application of his endless railway to the wheels of traction engines, principally with a view to the handling of guns, etc. The first engine appears to have been produced by Bach, of Birmingham, from an old portable engine. Several firms subsequently engaged in their manufacture, and the engines were found to have great tractive power and to be particularly useful on soft ground; but, as the endless railway was exposed to very great wear and tear, their manufacture gradually died out."

The particular feature of Leahy's arrangement, as will be seen from the illustration reproduced above, was not the use of a chain track, but the provision of eccentric discs, on each side of the wheel, which lifted the chain track clear of the periphery of the wheel except at the actual bearing point.—ED., E.]

CHARACTERISTIC DESIGN FACTORS FOR PUMPS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. J. R. Finniecome is certainly to be congratulated on the very successful way in which he has combined so many characteristic factors, covering a complete range of pumps, by the interesting charts reproduced on pages 463 and 464 of ENGINEERING of December 13, 1940. He need only add a few lines indicating the efficiencies to be obtained to fill the commercial centrifugal-pump designer's cup of happiness full to overflowing. The data given for the three radial-flow examples compare very favourably with the details of corresponding commercial frames. The ratio $\frac{U}{C_0}$ and, therefore, d, the tip diameter, are on the big side, but this may be to provide a margin for impeller adjustment after test. The comparison also indicates that b, the tip width, refers to the width at the outer diameter d, in line with Professor Daugherty's treatment, which is based entirely on the exit width. Some authorities consider that calculations based on the proportions at inlet give a better measure of the capacity of a pump, if only for the fundamental reason that the fluid that can enter the impeller channels must be discharged. The very noticeable effect of pre-rotation, in the eye of the impeller, shows that the radial velocity at inlet is a very important factor.

The author states that the charts are based on "fundamental considerations," so the example of a propeller pump, in Fig. 3, must be taken seriously. If this pump, with a 9½-in. rotor, can give its designed output on test, it must belong to that class with efficiencies of about 92 per cent.

A number of reasons are given for the improved efficiencies of modern pumping plants. Are the improvements in the technique of testing satisfied with the usual single-hole gauge connection? The connection to the throat of a Venturi meter is made through a number of small holes, equally spaced round the circumference; a refinement which reduces the error to about 1 per cent. Compare this with the case of a propeller pump, where the efficiency can be varied from 69 per cent. to 86 per cent. by changing the pressure-gauge connection from one hole in the delivery flange to another diametrically opposite, the discharge branch being formed by a 45-deg. taper bend. The same effect probably occurs in the straight delivery taper of a centrifugal pump, since the stream must be very disturbed by following what may be termed a 360-deg. bend. Considering that the loss due to a bend in a pipe line does not occur so much in the bend itself as in the straight length following it, it may be doubted whether the velocity-head correction allowed in modern pumps is much more than an artful dodge to claim a higher efficiency.

No one thing will show a more beneficial result in both performance and efficiency than a drastic change in the methods employed in the making and assembling of cores. When it is realised that the path through a pump is bounded by surfaces formed by core sand, and that absolute fluid velocities, not to mention relative velocities, may be up to 80 ft. per second, it will be seen that nothing short of bottle-smooth surfaces will give optimum efficiency. It is doubtful, however, whether this suggestion will bear much fruit until such time as the "New Order" reverts to the old, when engineering establishments were controlled by engineers.

Yours faithfully,
G. URE REID.

Inzevar, Dollar, Clackmannanshire.
January 25, 1941.

OBITUARY.

PROFESSOR MILES WALKER, F.R.S.

ELECTRICAL engineers will learn with regret of the death of Professor Miles Walker, F.R.S., which occurred after an operation on Wednesday, January 22, at the age of seventy-three. He did a great deal of original work on the design of electrical machinery, and was well known as a forceful personality whose influence as an educationist was of much assistance to many generations of young engineers.

Miles Walker was born at Carlisle and after being educated at local schools was anxious to take up engineering. In deference to the wishes of his parents, who considered that that profession had little future, however, he began the study of law and, from 1885 to 1890, was articled as clerk to Messrs. Dobinson and Watson, solicitors, Carlisle. He passed his first law examination with honours in the latter year and, for a time, practised in London. The death of the senior partner of the firm by which he was employed and the receipt of a small inheritance from his grandfather, however, enabled him to abandon law for engineering. He therefore enrolled as a pupil at Finsbury Technical College, and, after passing through the electrical engineering course, became personal assistant to Silvanus P. Thompson, the principal. While holding this post he did a great deal of work on the preparation of the latter's monumental work on dynamo-electric machinery, assistance which was fittingly acknowledged in the preface. In 1897, he left Finsbury for Cambridge, where he obtained a scholarship at St. John's College and subsequently took first class honours in the Natural Sciences Tripos and in the Mechanical Sciences Tripos in 1899.

About this time, the Westinghouse Company of America, which was proposing to start works in this country, asked Sir Alfred Ewing, who was then Professor of Engineering at Cambridge, to nominate a number of men to go to the United States in order to study its methods. Walker was one of those selected and spent over three years in the shops of the company at Pittsburgh, during which time he obtained a great deal of valuable experience. On his return to England he was appointed designer of alternating-current machinery to the British Westinghouse Company, now the Metropolitan-Vickers Electrical Company, at their Trafford Park Works. While holding this position he was responsible for a number of improvements in the construction of electrical rotary machinery. He also invented the Walker self-regulating alternator and an electric harmonic analyser. During 1911 he was special lecturer on turbo-alternator and rotary-converter design at the Imperial College of Science, London, and, in 1912, he was appointed professor of electrical engineering at the University of Manchester with headquarters at the Manchester School of Technology. He held this position until 1932, when he retired with the rank of Emeritus Professor.

Professor Walker was the author of several textbooks and of a number of papers read before the Institution of Electrical Engineers and other scientific societies. The former included *The Specification and Design of Dynamo-Electric Machinery*; *The Diagnosis of Troubles in Dynamo-Electric Machinery* and *The Control of Speed and Power Factor of Induction Motors*. His more important papers included one on "Heat Paths in Electrical Machinery," which was read before the Institution of Electrical Engineers in collaboration with Mr. H. D. Symons in 1912 and was awarded the John Hopkinson Premium. He received the Institution Premium in 1918 for a paper on "The Supply of Single-Phase Power from Three-Phase Systems," and an Extra Premium for a paper on "The Theory and Performance of Phase Advancers," which he read in collaboration with Dr. J. J. Rudra in 1930.

Professor Walker became an associate of the Institution of Electrical Engineers in 1894 and was transferred to the class of member in 1907. He had served as Chairman of the North-Western Local Centre. He was elected a Fellow of the Royal Society in 1931 and held the degrees of Doctor of Science in the University of London and of Master of Arts at Cambridge. In 1932, he was president of the Engineering Section of the British Association and delivered an address on the "Call to the Engineer and Scientist," in which he pointed out that the world would be better if engineers were entrusted with the control of economic and social matters. In this, contrary to the views of his old professor, Sir Alfred Ewing, who was president of the Association at the same time, he accepted without question the whole mechanism of modern science and engineering, though he asked for a constitution of society which would enable it to be used more efficiently.

MR. J. H. SILLEY, O.B.E.

WE also regret to record the death of Mr. J. H. Silley, which occurred at Port Navis, Cornwall, on Friday, January 24, at the age of sixty-eight. He was a distinguished figure among British marine engineers and especially in connection with ship repairing.

John Henry Silley was born at Chepstow, Monmouthshire, and served his apprenticeship with Messrs. Edward Finch and Company, a firm of local shipbuilders. At the age of 20, he went to sea as junior engineer in Messrs. J. P. Corry and Company's Star Line, and attained the position of chief engineer before he was 30. Soon afterwards, he started an engineering business in partnership with Mr. John Weir, under the title of Silley, Weir and Company, who made his well-known smokebox door for cylindrical boilers. This concern became merged with that of Messrs. R. and H. Green, Limited, the Thameside shipbuilders, and a new company was formed, entitled R. and H. Green and Silley,

Weir, Limited, of which John Silley became managing director. This firm undertook a large amount of repair work for leading shipping companies on the Thames under his direction, and his experience in this field was utilised in the 1914-18 war, when, in conjunction with the late Mr. Allan Hughes, he was identified with the development of Falmouth as a ship-repairing centre. His interests in Cornish shipping affairs were increased when he became director of Messrs. Cox and Company (Engineers), Limited, and of the Falmouth Docks and Engineering Company. In addition to the work at the docks, he was responsible for the construction of a model village for housing the workpeople at the docks, and also built flats and bungalows near the works in both London and Falmouth, where retired employees could dwell with their wives at low cost.

Mr. Silley became a member of the Institution of Naval Architects in 1919 and was also a member of the North-East Coast Institution of Engineers and Shipbuilders. He joined the Institute of Marine Engineers in 1892 as an associate, eventually becoming member of council, vice-president, and finally president. In 1901, he was awarded the Denny Gold Medal of the latter body for a paper on "The Treatment of Boilers under Forced and Induced Draught." During his presidency, he was associated actively with the foundation of a new Guild of Benevolence.

MR. ALFRED DICKINSON.

MR. ALFRED DICKINSON, whose death recently occurred at Rhyl at the advanced age of eighty-five, was connected for many years as consulting engineer with the conversion of many of the original horse and steam tramways to electric working, and with the erection of a number of new installations.

Alfred Dickinson was born on February 29, 1856, and served his pupilage with Mr. Charles Sacré from the age of fourteen until he was twenty-one. For the next six years he held an appointment with the Manchester, Sheffield and Lincolnshire Railway, during part of which time he was in charge of the running sheds and workshops at Cornbrook. From 1883 to 1885 he was locomotive superintendent to the South Staffordshire Tramways Company and, for the next ten years, general manager to the same concern. During this period he converted a ten-mile section of the system to trolley working, an interesting feature about the equipment being that the wires were not suspended over the tramway track but were erected to one side, collection being made by a lateral trolley. This arrangement has never been widely used in this country, though it has found some application in Germany and other parts of the Continent. He also acted as consulting mechanical engineer to the City of Birmingham tramways.

In 1895, Mr. Dickinson retired from the service of the tramway company to set up in private practice in Birmingham. As we have said, he devoted himself particularly to the conversion and erection of tramway systems, among those for which he designed the lay-out and carried out the work being the systems at Barcelona, Madrid, Bordeaux, Brisbane, Durban, Hong Kong, Singapore, and Cape Town. In this country he was wholly or partly responsible for the lines between Kidderminster and Stourport, and Dublin and Lucan, as well as for the urban systems at Birmingham, Carlisle and Gloucester.

Mr. Dickinson was elected an associate-member of the Institution of Civil Engineers in 1889 and was transferred to the class of member in 1903. He was the author of a paper on "The South Staffordshire Electric Tramways," which was read before the Institution in 1893. He was elected a member of the Institution of Mechanical Engineers in 1890, but had resigned some time before his death.

CLAY INDUSTRIES EXPORT GROUP.—Mr. Norman Hurtley has been appointed chairman and Mr. H. Halliday, F.C.I.S., 12, Hartington-road, Buxton, Derbyshire, secretary of the Clay Industries Export Group. The Group has sub-groups for the sanitary fireclay goods, salt-glazed pipes and fittings, and refractories sections of the industry.

LINE PRODUCTION OF MACHINE TOOLS.

THE terms "line production," as applied to the manufacture of machine tools, will be familiar to many engineers from the fact that it is sometimes used in connection with the moving-belt system employed in such industries as motor-car manufacture. As applied to machine-tool production, the machines are moved in line along the erecting shop and units are added at successive stages, at the last stage the completed machine being ready for final inspection. As the general practice of machine-tool makers hitherto has been to erect machines in batches, the line production method is sufficiently new to warrant some description. We accordingly give a brief summary of a paper, entitled "Line Production of Machine Tools," presented to the Manchester Association of Engineers by Mr. O. Rendell in November last.

Mr. Rendell commences his paper by a short survey of the causes which led up to the change of procedure in a particular works. The machines were originally made in batches of 12, all of which were erected in the same bay. Observation showed a great waste of time in collecting material from a common source and distributing the parts to the individual machines. As erection proceeded more or less simultaneously, delay occurred when the running-in stage was reached, since the inspection staff was naturally unable to deal with the whole batch at once. The machines were, moreover, ready for delivery in waves so that payment followed the same course and difficulties in forecasting the capital position arose. Moreover, erection of a fresh batch could not be started until the last machine of the first batch had been delivered. The batch system had proved quite satisfactory while the works was operating in a small way, but as the size of the works increased the system proved to be unsuitable.

The particular product handled on the line system is a horizontal boring machine with a fixed column and movable table and boring-bar stay. It is made in three standard sizes, but the several elements of each size are, in a sense, interchangeable. Thus the bed, column and boring-bar stay vary in length only, other dimensions being identical. The spindle saddle, again, is the same for all three machines, the only difference being in the sleeve, which is bored for one of the three sizes of spindle available. The main table and auxiliary rotating table, of course, vary with the size of machine, but these, too, can be changed about. All the machines are built for stock, manufacture commencing independently of the customer's orders as soon as the works and sales departments have agreed on the proportion of each size to be put in hand. Individual machines are regarded as composed of independent units, such as bed, gearbox, table, and saddle, and each unit has a separate works order number. The method of routing the units through the shops into the stores is described in some detail in the paper. One detail of particular interest is the recording of stock on cards of different colours according to the material used; red for high-carbon steel, green for nickel and other alloy steels, yellow for mild steel, and so forth.

It is clear that the methods employed in preparing the units could be equally well employed if the final erection were made according to either the batch or line methods, but the difference in the flow of work for the two methods is interesting. When the machines were finally erected in batches of 12, the first machine could be delivered in 60 working days and the last in 80 working days, so that they were all completed within a few days of one another. Line production, on the other hand, admits of both rapid production of the first machine and a more widely-spaced flow, though all the machines can be completed in less time than it took to get the first machine of the batch ready; thus, with line production, it is possible to deliver the first machine in 14 days and the twelfth in 54 days. There are two assembly lines in one bay of the shop. Unit No. 1, the bed of the machine, commences its journey east of the bay and travels west, and passes through five stations, at each of which a unit appropriate to it is added; racks, gearboxes and main drive boxes, boring bar stay, table, and so forth are added in this way. The second line has also five stations and commences west of the bay, the column forming its basic unit travelling east. The several secondary units are added in succession, and at the fifth station of each line the nearly-completed bed and column are together. They are then moved to the running and testing position, where the column is lifted on to the bed and all final tests are carried out by inspectors.

So far, the line method of production would seem to present no difficulties, but the author admits that these did arise. The chief reason for their occurrence was that the three sizes of machine mentioned above do not form the sole products of the works. The machines built on the line method average 3½ tons in weight, whereas other machines, which vary in weight from 8 tons to 25 tons, are also manufactured. This naturally tends to upset the loading of the production machines, and the greatest of the difficulties encountered was that of choosing the order and time at which each part should be machined in order to maintain a constant flow to the line erection bay as well as to the other machines under construction. The problem has been solved, to a great extent, by the adoption of what is called a horizontal planning chart. Briefly, this consists of a chart with horizontal divisions marked for the machine used in production. The division appropriated to each machine consists of a metal slide. Across the top of the chart is a time scale graduated in half inches and representing in its whole length one month. Strips of cardboard equal in length to the estimated time for a particular operation and bearing particulars of the part concerned, are inserted in the metal slides along which they can be moved freely. As the length of each strip denotes the time taken by the operation concerned while its position indicates that portion of the month occupied by the operation, it is a simple matter to allocate the whole work to be done among the available machines. If a whole line is filled by the cardboard strips it is clear that the machine in question is loaded to capacity for one month. Conversely, gaps in a line indicate that a certain machine is available for the times indicated by the gaps, reference to the top scale showing precisely the length of time and, therefore, days of the month, when the machine is not being used. The chart, however, would appear not to be capable of adaptation for parts which take under one day to machine, and the allocation of this work, chiefly done on lathes, milling machines and gear-cutting machines, is left to the foreman or charge-hand of a group of machines.

The remainder of the paper is occupied by some informative notes on certain operations. It is stated that the allocation of fitters on some of the line stations proved rather troublesome, chiefly due to the scraping of the ways for the sliding parts, the times for which varied by as much as 30 per cent. This disability has been removed to a large extent by grinding the ways instead of scraping them. The ways are, of course, first machined, reciprocating planing machines being used for this operation as well as for some surfaces which do not require either scraping or grinding. Plano-milling machines are not employed, the reason given being that, as much of the work has tee-slots cut from the solid, it has not yet been proved that milling cutters for this purpose can stand up for long periods of cutting. Typical reciprocating planing machines in use are fitted with two tool boxes on the crossbeam and one on each column and are driven by variable-speed electric motors. Cemented-carbide tools are now being used and the machining times have been considerably reduced. This type of tool, however, necessitates automatic lifting mechanism at the tool-box, so that it is lifted clear of the work at the end of the cutting stroke and remains thus during the return stroke. A cutting speed of 180 ft. per minute can be maintained and a very good finish is obtained when a cut is made with a wide tool and a coarse transverse feed.

Work which does not permit a clear run through is done on a crank-driven planing machine, this type being selected for the reason that high speeds can be maintained on it, whereas a planing machine driven by a reversing motor cannot be run at high speeds when the work requires accurate reversal. The author appears to consider that the limit for accurate reverse of a reversing-motor driven machine is a cutting speed of only 40 ft. per minute. As distinct from grinding of slide ways, a segmental grinding machine is used for producing the flat surfaces for the joints of feed-boxes, driving boxes, brackets, etc. As far as present experience shows, this is an efficient machine for flat surfaces with interrupted faces, but it is stated that it is very doubtful if its efficiency could be maintained when large uninterrupted surfaces are to be machined.

The decision to grind slideways was only made after very careful investigation. An interesting part of the investigation refers to some improvised experiments that were made to determine whether a surface-finish produced by grinding was as suitable for its purpose as one produced by scraping. Three cast-iron strips, 2 ft. long by 2 in. by 1 in., were made. One was hand-scraped after planing, one was ground by a wheel cutting on its periphery, viz., an edge grinder, and one by a wheel cutting on its face, viz., a cup grinder. Three cast-iron blocks, 2 in. cube, were prepared in a similar manner, and an attempt was made to determine if the pressure required to start the cube sliding on the strip differed when the different types of surface were in contact. It is stated that no definite results were obtained, which is hardly surprising, when it is considered that such experiments require a degree of refinement and a length of time which could not be provided in a works fully occupied in production.

On the question of grinding a surface 12 ft. long with an edge-wheel or a cup-wheel, there was sharp difference of opinion between the makers of the two types of

machine for slide-way grinding, but it is stated that no facts based on experiment were forthcoming. When considering what saving in time, if any, would be effected by substituting grinding for scraping, the estimates given by the machine makers had to be relied upon. The estimated grinding times proved to be reasonably accurate, and the saving in time over scraping by hand turned out to be between 4 to 1 and 6 to 1, varying with the work being ground. This result, translated into actual times, means that if a scraped surface takes 48 hours to finish by hand, it can be ground in from 8 hours to 12 hours. When the grinding of the slide-ways was first commenced, the main bed only was ground and the saddle sliding on it was scraped, as it was anticipated that lubrication troubles might arise if two ground surfaces were in contact. Subsequent trials proved that this fear was unfounded, provided that the surfaces were lubricated under pressure and that ample oil grooves were cut. The last point of the account of the preliminary investigations deals with the question of grinding parallel surfaces, such as the underside of a slideway over which the saddle hold-down strip moves. The result may be summed up by stating that, although these surfaces are ground, the strips are finally adjusted by hand scraping.

In connection with this part of the machine, it may be mentioned that the fitting of the taper gib provided for wear adjustment caused some trouble when erection in a line was started. When building was done in batches of 12, the planing department let in the taper gibs when the saddles were in place on their slideways, but this practice when building on the line caused undue interference with normal production in that department. To avoid this, a simple one-purpose milling machine was constructed. The spindle is driven by a 1-h.p. motor and the table feed by a ¾-h.p. motor, and there is only one spindle speed and one table feed. The table is provided with three permanent-magnet chucks mounted in a taper seating of the same inclination as that to which the taper portion of the saddle concerned has been machined. The taper gibs are issued from the stores to the station on the line at which the gibs are fitted, and are supplied about $\frac{1}{16}$ in. thicker than when finally fitted. The fitter himself machines the taper gib on this special machine to the appropriate thickness, so that there is no interruption of any other work, and the gib is finally adjusted by hand scraping. Although this machine only runs for about three hours at intervals of two or three days, it is stated to have justified its construction fully.

Another simple machine has been provided for cutting the oil grooves in the sliding parts. Previously, these grooves had been chipped by hand before the surfaces were ground, an operation which was lengthy, and not wholly satisfactory from the point of view of appearance. The groove-cutting machine, which is portable and is bolted to the work to be grooved, has a cutter in the form of a pointed dee-bit driven by a ¼-h.p. motor. The spindle head is carried on a beam along which it is traversed by means of a hand-operated screw. It is suggested in the paper that a tendency towards simplification of certain types of machine tools would be helpful in these days, when the quantities to be produced are generally large and the work can be split up into a number of simple operations performed on simple machines. The general manufacturing engineer has now grown to rely on the machine-tool maker to enable him to produce his output. He could help himself in many cases by making small special tools at much less capital cost than a universal machine.

EXAMINATIONS IN SANITARY SCIENCE.—The dates and centres, in Great Britain, of examinations of the Royal Sanitary Institute and the Royal Sanitary Institute and Sanitary Inspectors' Examination Joint Board, have recently been announced. Examinations for sanitary inspectors qualifying for appointments in England and Wales are to be held at Cardiff from March 20 to 22; at Newcastle from April 17 to 19; in London from April 24 to 26, from July 17 to 19, and from January 8 to 10, 1942; and in Liverpool from June 12 to 14. Examinations in sanitary science as applied to buildings and public works, and in general hygiene and sanitation, qualifying for the associateship of the Institute, are to be held in London from April 24 to 26 and from July 17 to 19. Examinations for sanitary inspectors in tropical hygiene are to be held in London from July 17 to 19; for smoke inspectors, in London, from April 24 to 26; and for sanitary inspectors for appointments outside England and Wales, in London, from July 17 to 19. Finally, examinations, qualifying for membership, in advanced knowledge of a sanitary-inspector's duties will be held in London, from April 24 to 26. Entry forms, which should be returned as soon as possible, and further particulars, may be obtained from the Secretary, Royal Sanitary Institute, 90, Buckingham Palace-road, London, S.W.1.

LABOUR NOTES.

WHEN the House of Commons reassembled on Tuesday last week, Mr. Ernest Bevin, the Minister of Labour and National Service, gave an exhaustive survey covering all the aspects of war-time industry, declaring in the course of it that it would soon be necessary to have industrial registration by age groups. There would be, in the coming months, he said, heavy demands for additional man power and woman power for the Services, munitions work and civil defence. In order to fulfil the requirements of the Services, there would have to be a reduction of the numbers in reserved occupations and further age groups would be called up. Before long, it was expected, arrangements would have to be made for registering men of 19 as well as men over 36 years of age. Since the resources for the additional requirements of munition work would thus be depleted, the Government proposed to tap unused resources and to ensure that the country's labour force was used to the fullest possible advantage. The reservoir of unemployed men was running dry, and the problem of greater recruitment of labour from non-essential occupations, of whatever rank, and from the unoccupied, had now to be faced.

It would have to be laid down, the Minister went on to say, that in certain types of vital war work the right of dismissal, except for misconduct, must be taken out of the hands of employers. Similarly, no employee would be allowed to leave vital employment without the permission of the National Service officer. After explaining the new machinery, described recently by the Prime Minister for exercising ministerial supervision over production and economic matters generally, Mr. Bevin assured members that there need be no fear of inconsistencies or divergency of policy as between the new executives; the Prime Minister had retained the responsibility for ensuring that the executives carried out the policy of the War Cabinet. Dealing with the criticism that sufficient use had not been made of the wide powers granted to the Government, Mr. Bevin said that in the main, he regarded those powers as sanctioning in the background, although in some cases they had been exercised. Unless that question were handled with very great care one might easily do more harm than good and injure the war effort.

Speaking in the same debate on the following day, Mr. Churchill said that in the next six months we should have, for the first time, an intense demand upon our man power and upon our woman power. We were now about to enter for the first time in this war the period of the man-power problem, because for the first time we were going to have the apparatus and lay-out that this man power and woman power would have to handle. That was the reason for the very far-reaching declaration which the Minister of Labour had thought it necessary to make to the House and the country. Now was the time when the full war effort would gradually be able to be realised as the plants came into being. The extra shell-filling factories which were a great draw for women were now only coming into being as they were constructed after the outbreak of war. He had thought for some time that the Army and the Air Force—the Navy not so much—had a great need for what he ventured to call combing their tails in order to magnify their teeth.

Continuing, the Prime Minister said that he believed there was, in the case of the Army and the Air Force, considerable scope for the saving of man power in the rearward and preparatory services in order to develop the highest economy and the highest manifestations of fighting power. He looked to very considerable combings and scrapings in the Air Force and the Army—particularly in the Army—not in order to cut these forces down—but in order to reduce their demands upon the man-power market as far as was possible considering the coming stringent months so that it might be possible to man the new factories and shipyards and the new plants that were coming into production. Both these fighting departments were engaged in that process at the present time, and the Army, in particular, was making very considerable savings from their rearward services in order to promote and carry forward the sharpening and expansion which were necessary.

"While the Army," Mr. Churchill said, "is growing every week in strength, power, efficiency and equipment, and while a decisive expansion of the Air Force is in progress, it is the munition factories and agriculture rather than these fighting services, which will, in the next five or six months, make the chief demands for man power upon the public."

The awards of the National Arbitration Tribunal on the applications of the engineering and shipbuilding trade unions for increases of wages were issued last week. The Amalgamated Engineering Union and the National Union of Foundry Workers had claimed from the Engineering and Allied Employers National Federation an increase of 3*d.* an hour on the basic rate and full restoration of certain working conditions in force at June, 1931. In their award, the Tribunal say:—"Statements were made and documents submitted as to the number of workers affected, the present basis of remuneration, the course of basic rates of wages and bonuses in the trade since 1917, average earnings in the trade at various periods, the difference between the pre-June, 1931, and present working conditions, changes in the economic and financial conditions in the industry, changes in the cost-of-living index figure, rates of remuneration and changes in rates of remuneration and in average earnings in other industries, the estimated cost of the proposed increase in the basic rate, the incidence of taxation among different classes of the community, and the anticipated results on the national economy of a wage increase."

"The Tribunal," the award continues, "have given careful consideration to the statements and submissions of the parties. They have had regard especially to the course of wages in the industry over a number of years and the extent to which, up to the time of the hearing, wages have been adjusted to the conditions of the present time both in the engineering industry and in general. They award that the national bonus be increased by 3*s.* 6*d.* a week in the case of all adult male workers, such increase to be applied in the same manner as the existing national bonus. The Tribunal find against the claim for the restoration of the pre-June, 1931, working conditions, and award on this point accordingly. The award shall have effect as from the beginning of the first full pay period following January 20."

The Engineering Joint Trades Movement, of which neither the Amalgamated Engineering Union nor the National Union of Foundry Workers is a unit, had claimed from the Engineering and Allied Employers' National Federation an increase of 10*s.* a week for time workers and an equivalent advance for workers employed on systems of payment by results. The Tribunal awarded an increase of 3*s.* 6*d.* a week in the national bonus. The Confederation of Shipbuilding and Engineering Unions, which consists of practically all the unions composing the Joint Trades Movement, had claimed from the Shipbuilding Employers' Federation an increase of 10*s.* a week for shipyard time workers, with an equivalent advance for men employed on systems of payment by results. The Tribunal awarded, as in the two other references, an increase of 3*s.* 6*d.* a week in the national bonus. These awards are also to have effect as from the first full pay period following January 20.

Industrial News, a publication of the Trade Union Congress, states that affiliated unions have been informed that the Joint Consultative Committee to the Minister of Labour has had under consideration the question of "staggering" the weekly pay day in order to avoid the week-end rush in the buying of household commodities. When, it is pointed out, the main shopping of the workers' family has to be carried out, in a few hours on Saturday, many difficulties arise which are intensified under war conditions. Earlier pay days, it is believed, would help not only the workpeople concerned in transport and distribution, but would also facilitate the working of the rationing system and the control of prices. It has been noted, moreover, that the concentration of household buying on Fridays or Saturdays has affected, to some extent, even the prices of uncontrolled commodities, which have a knack of rising a halfpenny or so in the "rush" of Saturday buying and selling.

The Joint Consultative Committee has approved the suggestion of the Ministry of Labour and National Service for the "staggering" of pay days and trade unions affiliated to the Trades Union Congress have been advised of the proposal with the object of enabling them to work out arrangements locally. It is recognised that it may be necessary to adopt different pay days within a single industry or even a single undertaking, or to "stagger" them. It is, therefore, regarded as necessary that the parties concerned, employers and representatives of the workpeople, should work out their own arrangements. It is hoped that by joint agreement also, any difficulty arising in connection with the change-over to an earlier pay day, which might mean lighter pay packets in the week of the change, may be settled.

THE ENGINEERING INSTITUTE OF CANADA.—The fifty-fifth annual general meeting of the Engineering Institute of Canada will be held at Hamilton, Ontario, on Thursday and Friday, February 6 and 7.

MECHANICAL GEARING FOR LARGE POWER TRANSMISSION.*

By L. M. DOUGLAS.

(*Concluded from page* 60.)

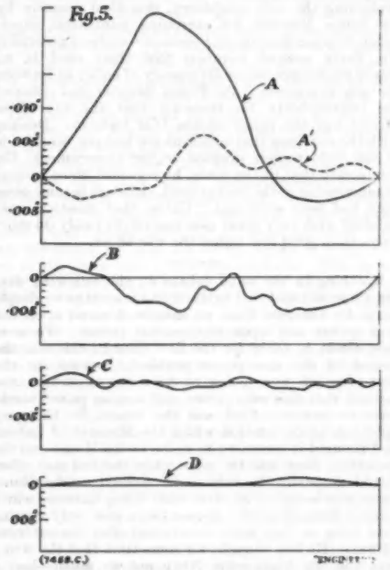
WHEN a satisfactory method was devised for measuring angular-pitch errors, by far the most important step in eliminating them, or at all events in reducing them to negligible dimensions, was accomplished. The progress in the attack on this problem by the author's firm indicates what has been done in this direction. It is shown by the curves of Fig. 5, herewith, in which the error scale has been greatly exaggerated. Curve A shows the angular-pitch errors of one helix of a double-helical wheel, 78 in. in diameter, before recutting in September, 1922. The total amplitude of the error curve is 0·033 in., and, while this is to a considerable extent due to eccentricity, and therefore even at that time inexcusable, it does give some idea of the kind of gears that were put into service prior to that date. Curve A′ is for the same helix after recutting, and it will be noted that the error-curve amplitude is still 0·009 in. Curve B shows the errors of a 50-in. diameter spur-tooth master wheel of a gear-cutting machine, measured before correction, the total error being almost 0·007 in. Its error is mainly of an oval character and has no noticeable eccentricity.

The first assault that was made on these errors might be properly described as a herculean task. This 50-in. wheel was first gauged in 10 spans of 25 pitches each. Then each of these spans was gauged in 5 spans of 5 pitches each; finally, each of the 5 pitches of the smaller spans was gauged individually. By this means a complete chart of the angular-pitch errors of all the teeth was obtained. Using a tool-post grinder attached to the head of a slotting machine, each tooth flank was then ground by the requisite amount to bring it to the correct pitch. The circumferential-pitch gauge was used to measure the amount of metal removed, being applied to a tooth flank before grinding and after each stroke of the grinding tool. This arduous process occupied over three months of long and tedious days. Curve C shows the errors of a 96-in. diameter worm wheel, cut on a machine using the 50-in. master wheel of Curve B, after this rectification. The error is only about 0·0025 in., which, for a wheel of that diameter, was considered a good achievement. However, as might be expected after the treatment referred to, there is a lack of smoothness in this curve, and as the inclination of any part of the curve to the horizontal datum line indicates the rate of acceleration required to accommodate the error, the improvement is not so great as the smallness of the total error suggests. However, this was an important step in the attainment of accuracy, as it cleared the ground very considerably for the next and final process.

That process consisted in lapping an 80-in. diameter spur master wheel with a crown lap, which completely encircled the master wheel and had teeth equal in number and complementary in shape to those of the wheel. The external teeth of the master wheel and the internal teeth of the lap were cut to the highest accuracy possible. The lap was secured to the bed of a large slotting machine and the master wheel to the reciprocating slide. Torque was applied by springs between the two, to press the teeth into contact on one set of flanks, and the wheel was reciprocated with the appropriate stroke parallel to its axis. A suitable abrasive material in oil was applied to expedite the grinding. After a certain amount of lapping in one engagement, the relative angular position of engagement was altered, and so on till this lapping had been done in every angular position of engagement. The process was carried on until the wheel fitted the lap equally well in any angular position of engagement, which indicated that the teeth of both wheel and lap were equally pitched about a common axis, and that errors corresponding to harmonics of every order but the first, the purely eccentric error, had been eliminated. After completion of the lapping, which occupied three months, circumferential pitch gaugings were taken; the errors in angular pitch derived therefrom are shown in curve D for one set of flanks. It appeared from this that there was still an error of 0·001 in., but it was not found possible to improve upon this result by further lapping. It then became apparent that this limit was a question of the accuracy of the method of gauging, rather than of the accuracy of the wheel. An interesting reversal of function had taken place; the wheel teeth were so true in pitch that they had become a test of the method of gauging and showed up its limitations. It has been stated that the gauge is restrained axially and radially by stops. The stops for axial restraint engage the end face of the wheel, and the radially restraining stops engage the periphery. If the end face is not perfectly flat and at right angles to the axis of the wheel, or if the periphery is not perfectly round and co-axial, the errors thereof will be reflected in the gaugings. The measured error is of the second order and could be produced by lack of flatness of the end face, but it is extremely unlikely that it was; it is more probable that it was caused by the end face not being at right angles to the axis, and most probable that it was caused by the periphery of the wheel being slightly oval.

No attempt was made in the lapping process to remove the first order or eccentric error; and, in order to obtain the full advantage of an otherwise true master wheel, it is essential that its teeth be co-axial with the table stalk or journal, which must be perfectly round, while the fixed and moving faces which restrain the table axially must be truly flat, and at right angles to the axis of rotation. These desiderata are attainable by ordinary methods.

The load-carrying capacity of gears is directly affected by the amount of flank surface which comes into contact when the gears are engaged dry, and also by the nearness to contact of the other portions. Although the oil film is exceedingly thin, if the "non-contact" portions are very shallow, the oil film at these parts will not be much thicker than it is at the "contact" portions, and will consequently sustain some portion of the load. The tooth flanks of a gear which has been run into perfect contact have a mirror-like polish over the whole surface. It is not possible to attain this polish in practical manufacture, but the contact portions of the teeth quickly acquire it in operation. The aim, therefore, is to obtain full contact with a reasonably good surface.

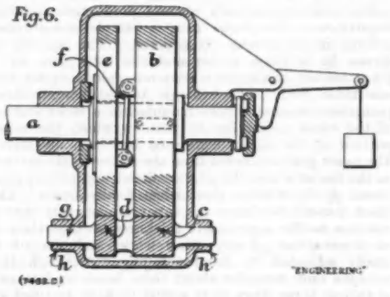


To obtain such a finish, it is necessary to rectify the principal slow-motion members of the creep mechanism. The creep effectively distributes the errors of its mechanism, but it only partially eliminates them. The early creep-cut gears had pronounced cusps or creep marks, and it was obviously desirable to reduce these considerably. This has been done fairly successfully, and gears cut on a modern first-class machine with creep mechanism certainly have quite a good finish. This has been achieved mainly by removing the angular-pitch errors from the members of the creep mechanism; a relatively simple matter, once a really true master wheel has been obtained.

Changes of temperature, usually diurnal, during the cutting of wheel teeth, must be avoided, as they cause circumferential bands of high spots. The first cases observed were caused by the radiant heat of the sun. The machines were in a shop with a glass roof. During the day, the sun shone down on the work, which absorbed the heat and shielded the machine, with the result that the work expanded relatively to the machine and increased the penetration of the hob. During the night, the work contracted to its normal dimensions and normal hob penetration. It was thought at this time that, as general changes of temperature of the ambient air occur so slowly, they would not have any disturbing effect. However, with the installation of an improved heating system for the building it was found that, unless the day-time temperature was maintained during the night and during week-ends, bands of high spots were formed on the wheel teeth. If the wheel has diurnal bands (or if the pinion has hob marks) the engagement is reduced substantially to point contact—the intersection of two lines. This matter is of such importance that the author's firm have recently gone to the length of building a new shop solely for the purpose of housing gear-cutting machines. It is specially designed to avoid these thermal effects, being provided with north lighting and automatic temperature control.

So far, machines have been referred to in general terms, and what has been said in regard to them applies equally to wheel and pinion machines. There is one point, however, which should be referred to in connection with pinion machines; since the pinion has n times the rotational speed of the wheel, if its angular-pitch errors are to have no greater accelerating effect than those of the wheel, they should not be more than $\frac{1}{n}$ times their magnitude. Logically, therefore, the master wheel, etc., of the pinion machine should be as large as that of the wheel machine. As a practical measure, it is not actually necessary to go so far as that, but it is certainly desirable to provide the pinion machines with relatively large-diameter indexing mechanism.

Lubrication of gears of the high-speed type has proved to be remarkably free from difficulties. The essentials are suitable quality, quantity, application, and drainage of the lubricant. Quality can be ensured by stipulating conformity to a British Standard specification, in which the methods of testing are in accordance with the recommendations of the Institution of Petroleum Technologists. In addition to the oil being generally good in quality, it is necessary that it shall have a suitable viscosity at a temperature corresponding to reasonable operating conditions. As in journal and pivoted thrust bearings, the higher the viscosity the greater the friction, but the loss by the friction of the intermeshing teeth is so small that this consideration can be neglected within reasonable limits. For given conditions of velocity, etc., a more viscous oil will produce a thicker film, and consequently will distribute the load over a greater width or zone of the contacting surfaces and thus increase the load-carrying capacity. What temperature the film attains is not known, but the viscosity at a normal temperature may be taken to represent, roughly, the influence on load-carrying capacity. In deciding upon the viscosity, another important consideration arises: if the same oil is to be used in the bearings of the system, its suitability for lubricating these also must be considered. The total frictional loss in the bearings, including the turbine bearings, is usually very small—of the order of 1½ per cent. of the power transmitted—but it must be kept small, and this tends to place an upper limit on the viscosity, since it is not practicable to increase the clearances of the turbine bearings to enable them to use a more viscous oil with the same frictional loss. A viscosity at 110 deg. F. of 250 seconds Redwood No. 1 is a satisfactory compromise. It would be possible to effect some saving in the size of gears by having two separate lubricating systems for the gear teeth and the bearings, but the complication is not considered justifiable. Some years ago, the Parsons Marine Steam Turbine Company devised an arrangement in which the same oil was used throughout the system, but that supplied to the gear teeth was cooled to a greater extent than that supplied to the bearings. This is a simpler arrangement than having different oils and separate systems; but it was not considered to be worth while, and, after use in a few marine installations, was discontinued. As in film-lubricated bearings, the amount of oil that passes through the actual load-sustaining film is extremely small, and the amount supplied is determined by the need to carry off the heat generated by the frictional loss.



Application is also exceedingly free from difficulties. The oil is usually supplied by nozzles or sprayers through which it is directed on to the periphery of one or both gear elements at or near to the inter-mesh. If the jet of oil impinges on the periphery of either wheel or pinion at any point within the common tangent on the incoming side, it is impossible for it to escape without passing through the intermesh, provided the gears are

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne, on Friday, November 29, 1940. Abridged.

rotating at sufficient speed to throw the oil off centrifugally. When it is thrown tangentially from one member it must strike the periphery of the other inside this common tangent, whence it will be thrown, again tangentially, back to the first member and so on, each time nearer to the intermesh through which it must eventually pass.

In regard to distribution across the width of the gear, in the early days of high-speed gears several devices were suggested, and in a few cases adopted, for spreading the oil fan-like as it leaves the sprayer; for example, one proposal was the exact equivalent of the Bray gas burner and the effect was the same, the oil being delivered in a thin, flat, fan-shaped sheet. However, with helical gears, such devices are entirely unnecessary. The intermeshing gears act as a pump, forcing the oil axially across the face in the same direction, and presumably at substantially the same speed, as the line of contact. This can be clearly observed when gears are rotating very slowly. There is no doubt that, if all the oil were supplied at a point just inside the end of the face at which contact commences, helical gears would be quite satisfactorily lubricated. The usual practice, therefore, of delivering the oil through a series of jets equally pitched across the face width fully meets all requirements; it is usual for this to be done on the incoming side, with the jets directed on to one periphery within the common tangent. Adequate drainage of gearcases is very important. If the head of oil necessary to produce the required flow to the drain tank is such that the oil level reaches the periphery of the wheel, the oil is liable to be entrained by the wheel and whirled round the gear-case. This causes an alarming loss of power and would quickly cause deterioration of the oil. The action can then only be stopped by reducing the speed of the wheel.

It is desirable that gear pinions should be in good dynamic balance, but static balancing is usually all that is necessary for the wheel, as its rate of revolution is invariably so low that any unbalanced couple set up through lack of dynamic balance is too small to cause disturbance. The efficiency of mechanical gearing is so high that little attention has been paid to accurate determination of the actual losses in transmission. The main consideration is to estimate the losses sufficiently closely to ensure that the supply of lubricating oil is adequate. The losses in the journal bearings, which are dependent upon their bearing surface, surface speed, oil clearance, etc., can be estimated from known data, but there is little published information regarding the losses due to the teeth engagement.

Fig. 7.

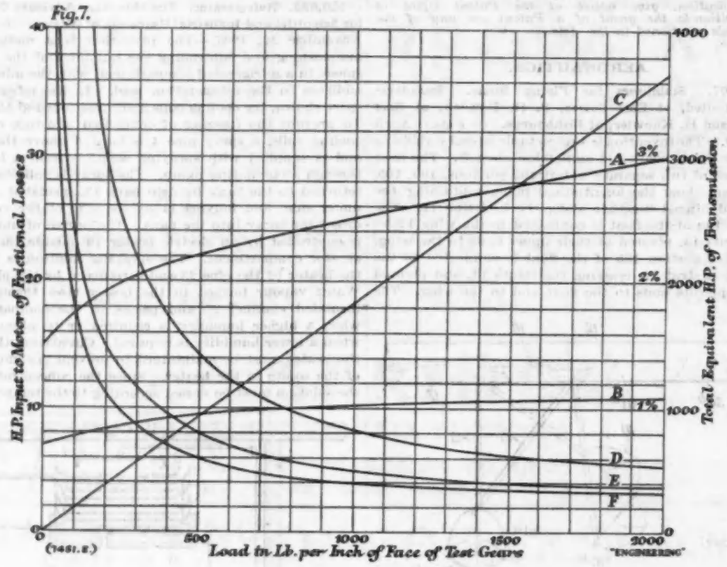
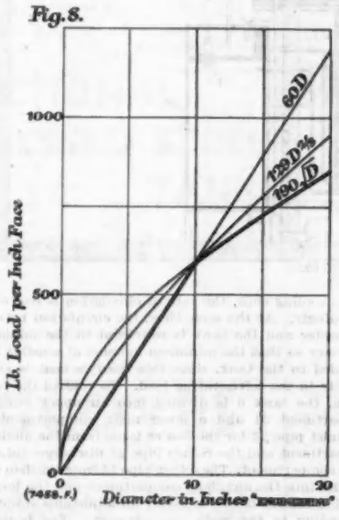


Fig. 8.



One attempt to get some data regarding this loss was made with the gear-testing apparatus at Turbinia Works. This plant is shown diagrammatically in Fig. 6, opposite. On the shaft *a*, driven by an electric motor, is secured the "opposing" gear *b*, which engages and drives the small gear *c*. The latter drives the test pinion *d*, which is secured to the same shaft, and the test pinion drives the test wheel *e*, which rides on shaft *a*. Means, here indicated by links *f*, are provided to prevent relative rotation between gears *b* and *e*, while allowing them relative axial freedom. Load is applied to gears *b* and *e* through thrust blocks to press them axially towards each other. This apparatus is designed solely for testing gears, but it was used in the following manner to measure approximately the frictional loss at the teeth intermesh. Tests were carried out at given loads, speeds, oil temperatures, etc., and the electrical input to the driving motor measured. The shaft *g*, carrying gear *c* and test pinion *d*, was then removed and a similar series of tests carried out with load applied to the thrusts as in the previous tests. The power required to drive the apparatus is greater in the first series, the difference being due to the frictional resistances of the teeth engagement and of the journal bearings *h* of the shaft *g*. If the resistance of the bearings *h* is deducted from the difference, the remainder is the loss due to the teeth engagement.

Fig. 7, on this page, shows a typical series of curves obtained by one set of tests at a constant speed of 100 ft. per second at the pitch line, a constant oil-supply temperature of 100 deg. F., and a load on the gears varying from zero to 2,000 lb. per inch of face of the test gears. The load rating of the opposing gears is half that of the test gears, because the former are twice as wide. Curves A and B indicate the horse-power input to the driving motor, respectively, for tests with and without shaft *g*. Curve C indicates the horse-power of transmission to which the load on the teeth and the peripheral velocity correspond. Curve D is the difference between curves A and B, expressed as percentage of the power (curve C), and curve E is the same minus the estimated loss in bearings *h*. The percentage loss at the test-gear teeth is less than that indicated by curve E, since half the transmission is at half the load rate of the test gears, to which these curves are plotted, and the percentage loss increases with decrease of load rate; and curve F is the percentage loss at the test-gear teeth as computed from curve E. This differential kind of measurement is never very accurate, although in this case the difference is quite large in relation to the measured values; the accuracy of the estimate of the losses in bearings *h* cannot be guaranteed; and, finally, these tests are rather of a preliminary nature as, owing to the outbreak of war, they were discontinued before check tests were made. However, despite these necessary qualifications, curve F probably represents fairly well the frictional loss in the inter-mesh. It will be noted that, at normal and high rates of loading, the loss is very small; for instance, at a load of 1,000 lb. per inch face, it is barely 0·4 per cent.

For low-speed gears, the maximum permissible load varies as the relative curvature of the teeth and, therefore, as the diameter of the pinion (the curvature of the wheel teeth is usually neglected); and the Hertz equation can be used to determine the stress. With a high-speed gear, however, the intervening oil film distributes the pressure differently, and the "D × constant" rule cannot be solely relied upon. If it is considered that the oil film is effective over the zone in which its thickness is not increased beyond a certain constant amount, then the limiting load should vary as $\sqrt{D}$, and in the absence of precise knowledge in the early days, limits in accordance with both D and $\sqrt{D}$ were prudently adopted. Apart from any theoretical considerations, these two limitations had the great virtue that they prevented the adoption of excessive loads with either very small or very large diameters of pinions.

The pressure distribution by the oil film is still not known with any degree of precision, but theoretical investigation indicates that the load-carrying capacity should vary as $D^{\frac{4}{5}}$; in Fig. 8, herewith, curves are shown for load variation in accordance with D, $D^{\frac{4}{5}}$, and $D^{\frac{1}{2}}$, with a common value for a 10-in. diameter pinion. The limits actually adopted are shown in thick lines, and their proximity to the $D^{\frac{4}{5}}$ curve justifies the prudence exercised in the adoption of those limits. These rules are probably defective in that they do not take velocity into account. This lack has been covered up to some extent by the facts that the tooth speed of marine gears does not vary violently, at all events for similar types of ship, and that the load probably should only vary as $V^{\frac{1}{4}}$. The advisability of amending the rules to include a velocity factor is under consideration.

The main scope for further improvements is in the finish of the gears and the quality of the materials. Some light on the possibilities of such improvements may be gleaned from what is being done in the production of aeroplane gears, in which it has been possible to attain the minutest accuracy and finish by lapping, etc. In a recent publication by one firm manufacturing such gears, loading rates are advocated which are approximately nine times the limiting values used with marine turbine gears, and there is no reason to doubt the claim that the gears will operate satisfactorily with such loading rates. This high rating is clearly due partly to the use of higher-quality steel and partly to the great accuracy and finish which is a practical possibility with gears of this size. Extreme-pressure lubrication is not employed in this case. Full particulars of the material specification are not given, but it is improbable that the quality and treatment of the steel are responsible for the loading rate being more than doubled; and, assuming this to be so, the further increase in the loading rate must be of the order of four or five times, as a result of obtaining full initial contact. In the gear-testing apparatus at Turbinia Works, gears which had full contact surface were run quite satisfactorily with load equal to 300 D, and since the gear ratio of the apparatus was only 5 to 1, this is equivalent to a loading rate of 330 D, with the usual ratio of about 10 to 1. There was no evidence whatever that this rate, which is 3·3 times the usual maximum, was approaching the limit. A set of gears was recently inspected of which, after 14 years' service, only 50 per cent. of the ahead and less than 20 per cent. of the astern flank surface was effective, and it is questionable if more than 10 per cent. had been effective when the gears went into operation. There was a small amount of pitting, which had clearly resulted from the early operation, but it was of no consequence; and, although the gears must have had initially about ten times the nominal load rate, they were working throughly satisfactorily and have never given any trouble at any time.

There is much evidence that, with perfect finish, loads much higher than the present maximum can be carried. Any improvement in the steel employed must be in the direction of an increase in the fatigue limits without sacrifice of ductility. It is probable, however, that increased fatigue limits will be accompanied by increased hardness; but hardness cannot be increased with impunity unless the gears are made microscopically perfect, as the local stresses induced by any excrescences on the tooth flanks will increase with the hardness. It is clear, therefore, that

improvement in finish must precede increase in hardness.

It is a practical possibility to cut a very accurate pinion with a good finish which can be further improved by polishing or lapping, but it is hardly practical to lap the large heavy wheels of marine gears. There are other processes for improving the finish of gear teeth, but they are not readily applicable to large wheels. In the author's opinion, it is not good practice to run a gear with abrasive so that the wheel and pinion lap each other. The practical solution seems to be to perfect the gear-cutting machines and operate them under such conditions that they will produce gear wheels having the desired accuracy of form and finish, without recourse to other processes. With such large wheels and machines as are required for large-power transmission, the task is not an easy one, but it is clear that it is along this road that progress lies.

It would be unfitting to conclude without paying tribute to the Engineer-in-Chief's Department of the Admiralty for the part they have played in the improvement in the quality of gears for large powers. Their early recognition of the importance of accuracy and their insistence on its attainment have unquestionably had a most salutary effect and have been a source of encouragement to those engaged in the task.

SAFEGUARDING OF AIR RECEIVERS.

IN ENGINEERING of June 7, 1940, we gave an account of the explosion of a large air receiver. The cause was concluded to be that oil from a hydraulic press which the receiver served had leaked back and vaporised, the vapour subsequently igniting with the development of sudden and abnormal pressure. Particulars of a similar case are recorded in the January issue of *Vulcan*, the journal of the Vulcan Boiler and General Insurance Company, Limited, 67, King-street, Manchester, 2. The receiver in question had a shell 25 in. in diameter, 67 in. long, and $\frac{1}{4}$ in. thick. There were no longitudinal seams, and the dished ends were fire-welded to the shell and $\frac{1}{4}$ in. thick. The certified working pressure was 100 lb. per square inch, but the explosion occurred when the receiver was under a pressure of just over 75 lb. per square inch, one end plate being blown off without warning. The compressor was not capable of raising the pressure above 150 lb. per square inch, so that the resultant stresses could not have been sufficiently high to cause fracture of the receiver.

Inquiry into the accident showed that the end-plate had been forced from the shell at the weld for about 7$\frac{1}{2}$ in., measured circumferentially, and that the shell itself had fractured for the remainder of the circumference, the break being from $\frac{1}{4}$ in. to 1 in. from the weld; this strip still adhered to the end-plate. The weld was of the ordinary standard accepted in fire welds. A metallurgical examination disclosed no evidence of a progressive fracture in any particular region, the indications being that the whole fracture occurred suddenly, commencing at the inner surface of the shell and proceeding in a brittle manner for about half the thickness of the plate, after which some indications of ductility were apparent. All the evidence went to show that defective welding was not a contributory factor to the failure, which was due to the application of pressure, much in excess of the compressor capacity, in the receiver.

The conclusion was that the air from the compressor was at a temperature exceeding the flash point of the lubricating oil used, and that this hot compressed oil-laden air provided an explosive charge. Ignition might have occurred from a spark developed by friction in the compressor cylinder; from heated dust particles; or from fragments of carbon heated to a glow by the high temperature of the compressor discharge. It is not suggested that the danger of such explosions is continuously present, since the proportions of air and oil vapour in the mixture may vary, and the mixture may not always be capable of being fired; at the same time, the risk is by no means negligible. To combat it, a fusible plug could be fitted in the compressor delivery pipe with advantage, the alloy of the plug being made to fuse at a temperature below the flash point of the compressor lubricating oil. A suitable plug has been developed by the Vulcan Insurance Company, and is made in two sizes for screwing into pipes below and above 2 in. bore, respectively. The screwed portion is prolonged internally into a plain tube, sealed at the top with the alloy and grooved to increase the heat conductivity. Externally, there is a hexagonal cap, bored on the faces with holes communicating with the hollow interior of the plug. The plug should be screwed into the discharge pipe as close as possible to the receiver. Should the delivery temperature of the air approach the danger point, the alloy fuses and allows the air to escape, with an audible warning sound, through the holes in the cap.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
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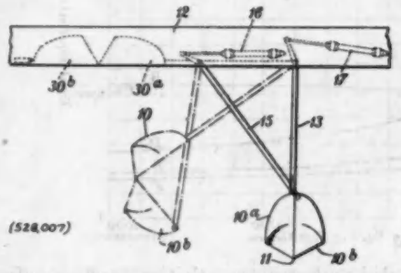
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

528,007. Stabilisers for Flying Boats. Saunders-Roe, Limited, of East Cowes, P. R. Dowden, of East Cowes, and H. Knowler, of Fishbourne. (6 *Figs.*) April 26, 1939.—The invention is a retractable lateral stabilising float for flying boats and amphibian aircraft. The float is formed of two separate watertight portions, 10*a*, 10*b*, separated along the longitudinal plane containing the keel and hinged together along the keel line 11. The portion 10*a* of the float is connected to the wing 12 by two struts 13, pivoted at their upper ends to the wing. The other portion 10*b* of the float is connected to the wing by a strut 15, crossing the struts 13, and pivoted at its opposite ends to the float and to the wing. The



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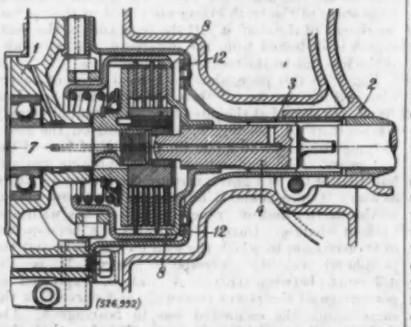
retracting gear consists of a pair of hydraulic jacks 16, 17, the piston rods of which are connected respectively to the struts 15 and 13. When the jacks are operated to retract, the struts swing about their pivots on the wing so as to retract the float laterally and inboard. As shown in chain-dotted lines, the portion 10*a* of the float swings bodily in an arc of a circle, while the other portion 10*b* of the float is constrained by its strut 15 to hinge away from the portion 10*a*, until finally, in the fully-retracted position, the previously contacting faces of the two portions of the float lie parallel to one another, and the two portions of the float occupy separate recesses 30*a*, 30*b* in the wing. Since the two halves of the float hinge apart, the depth of the recesses 30*a*, 30*b* need only be half the width of the float, so enabling the float to be completely retracted within the relatively small depth of the wing. The aerodynamic resistance of the stabiliser floats is thus eliminated. (*Accepted October* 21, 1940.)

MOTOR VEHICLES.

526,992. Motor-Cycle Transmission. Scott Motors (Saltaire), Limited, of Shipley, and W. Cull, of Shipley. (1 *Fig.*) March 31, 1939.—The transmission is for a light-weight motor cycle of the kind having provision for pedal



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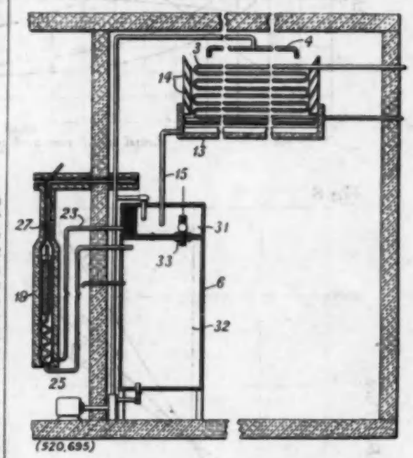
propulsion. In this type of cycle the engine shaft is clutched to an aligned propeller shaft, which drives a worm reduction gear housed in the bottom bracket of the frame and the invention is an arrangement whereby the transmission can be braked when the clutch is disengaged. The engine casing 1 is connected to the bottom bracket 2 of the cycle frame by a locating and supporting tube 3, which encloses the propeller shaft 4. Its forward end is bell-shaped to house the disc-type clutch between the engine output shaft 7 and the propeller shaft. The driven element 8 of the clutch is splined to the forward end of the propeller shaft and when fully disengaged its rear face engages a stationary brake lining 12, which constitutes a transmission brake. The clutch is fully disengaged before the transmission brake is engaged (see lower half of the figure) so that the intermediate position gives normal clutch disengagement. (*Accepted September* 30, 1940.)

MISCELLANEOUS.

520,695. Refrigerator. The Honorary Advisory Council for Scientific and Industrial Research, of Ottawa. (5 *Figs.*) November 22, 1937.—The invention is a method of maintaining and controlling the humidity of the atmosphere in a refrigerated compartment, with the minimum addition to the refrigeration load. In the refrigerator space shown, the cooling coils 3 are positioned at the top. To prevent the freezing of condensed moisture on the cooling coils, a spray pipe 4 is located above the coils and is supplied with spraying solution from a tank 6 through a circulating pump. The spray is collected and returned to the tank by drip pans 13, insulated on the under side, and louvres 14 at the side of the coils to direct the spray into the pans. The degree of humidity is controlled by an electric heater 19 outside the refrigerator compartment. The spraying solution is fed to the heater by the pipe 23 and is returned by the pipe 25. Water vapour formed in the heater rises through an insulated channel 27 and passes to the compartment when a higher humidity is required or to atmosphere when a lower humidity is required. Circulation through the heater must be maintained to prevent accumulation of the solute in the heater. Since the concentration of the solution must be varied according to the temperature



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of the cooling coils, the rate of circulation is controlled accordingly. At the same time, the circulation between the heater and the tank is restricted to the minimum necessary so that the minimum amount of sensible heat is added to the tank, since this sensible heat is added directly to the refrigerating load. To control the circulation, the tank 6 is divided into an upper auxiliary compartment 31 and a lower main compartment 32. The inlet pipe 23 for the heater leads from the auxiliary compartment and the return pipe 25 discharges into the main compartment. The return pipe 15 from the drip pans empties into the auxiliary compartment and the level of solution therein is controlled by an adjustable standpipe 33 leading to the main compartment. The heater is positioned so as to be fed by gravity from the auxiliary compartment. The rate of flow through the heater is determined by the level in the auxiliary compartment, which is regulated by the adjustable standpipe. The heater is automatically switched off in the event of stoppage of the spray. The heat required for humidification is reduced to a minimum by supplying the highest possible proportion as latent heat of vaporisation of the water solvent, instead of as sensible heat. In trials of the apparatus, the humidity was raised to over 95 per cent. and maintained at these values with the air temperature at 14 deg. F., and the mean temperature of the refrigerating surfaces at —1 deg. F. The thermal efficiency of these surfaces was 50 per cent. greater with than without the humidity control, under which latter conditions the relative humidity never exceeded 80 per cent., causing severe desiccation of the perishable foods stored. (*Accepted May* 1, 1940.)